DIVERSITY, BIOGEOGRAPHY, AND TAPHONOMY OF LATE CRETACEOUS CHONDRICHTHYANS FROM MONTANA

VOLUME I

By

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ABSTRACT

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The chondrichthyan fauna of the Late Cretaceous of Montana was last comprehensively reviewed by Case in the late 1970s. Collections from vertebrate lag deposits (2002 and 2006) from the Woodhawk Bonebed (WH) and Power Plant Ferry Bonebed (PPF) respectively of the Judith River Formation (JRF) add six additional species to the previous known diversity from the JRF, namely *Squalicorax pristodontus*, *Cretolamna appendiculata*, *Protolamna sokolovi*, *Ischyrhiza avonicola*, *Ptychotrygon hooveri*, and *Ptychotrygon triangularis*. These collections also include previously known species from the JRF, *Hybodus montanensis*, *Cretorectolobus olsoni*, *Squalicorax kaupi*, *Squalicorax* sp., cf. *S. kaupi*, *Hypotodus grandis*, *Hypotodus* spp., *Archaeolamna kopingensis*, *Archaeotriakis rochelleae*, *Protoplatyrhina renae*, *Ischyrhiza mira*, *Myledaphus bipartitus* and a chimaerid, *Ischyodus*.

The combined faunas from the WH and PPF and Case's studies (1978a and 1979) indicate that the JRF was a coastal, warm shallow marginal marine environment supporting a moderately diverse fauna of mostly lamniforms and rajiforms. Biogeography analyses of elasmobranchs from the Western Interior Seaway (WIS) show that 17 of the JRF taxa are endemic either to the JRF or to the end of the Cretaceous of the WIS. Also present are five cosmopolitan species. The species compositions of Case's study and this study differs, such that, the combined faunas produce a more comprehensive faunal list that is on par with contemporaneous faunas from similar

environments to that of the JRF, and that the JRF fauna along with the faunas of the Dinosaur Park Formation (Alberta), "Mesaverde Formation" (Wyoming), and the Hell Creek Formation (Montana) form the Judith River Province at the generic level in a Parsimony Analysis of Endemicity (PAE).

Most of the species collected are autochthonous; those found *in situ* are likely to be less abraded than material brought in, as evidenced by taphonomic experiments. Experiments also show that the two locations, despite close proximity to each other, show localized areas of variable energy that affected the faunal composition slightly, the abundance of material, and the quality of preservation. The WH is a higher energy environment where additional material from farther offshore is transported in and mixed with local material, resulting in a higher degree of abrasion of material compared to that preserved at PPF. This has created a mixed marine and estuarine assemblage, which in turn has produced mixed interpretations of the geology and paleontology of the JRF. The experimental approach applied here permits: distinguishing autochthonous from allochthonous fossil vertebrate hard parts, quantification of the amount of transport and wear, and clarification of the potential for postmortem effects such as the loss or distortion of diagnostic skeletal features. In the case of shark teeth, the root lobes and apex of the cusp wear down first, followed by other projections such as cusplets. Loss of these features suggests the effects of taphonomic processes. However, taphonomic insight is achieved at the cost of information on the taxon and the fauna overall. A preliminary product from these observations and experiments is a taphonomic scale that can be applied to moderately worn shark teeth to assess amount of wear and relative environment.

To the grandparents I never had the chance to know:

Ahmet Tulu
5 May 1911 – 15 March 1978

and

Ifakat Tulu
21 February 1921 – 7 September 1970

To the grandparents who went too soon:

Grandpa and Grandma,

Bernard Patrick Donnelly
30 July 1916 – 2 March 2003

and

Virginia Naghten Donnelly
25 March 1915 – 13 December 2001

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J. Alan Holman
24 September 1931 – 12 August 2006

And to my furry beloved sister:

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18 May 1995 – 23 December 2009

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KEY TO ABBREVIATIONS

Shark, ray, and chimaerid tooth terms

apx	apex
cr	crown
cus	cusp
enl	enameloid
lad	lateral cusplets (= denticles)
laf	labial foramina
lam	lamellar tissue
lif	lingual foramina
lu	lingual uvula
lpr	lingual protuberance of the root
mlu	median lingual uvula
nec	neck (= collar = lingual furrow)
nug	nutritive groove
oc	occlusal surface of crown
or	orthodentine
ot	orthotrabeculine
puc	pulp cavity
rt	root
tcr	transverse crest
tdn	trabecular dentine (or osteodentine)
vcn	vascular canal
ver	vertical ridges (= plications)

CHAPTER ONE

INTRODUCTION

The Cretaceous formations of Montana (Figure 1) have long been of interest to both geologists and paleontologists. The formations were first noted as early as the Lewis and Clark expedition from 1804-1806 (Lewis, 1814). Since that time the area, in particular the Judith River Formation (JRF) (notably in Fergus and Blaine counties), has been explored and studied for its geology and fossil fauna (in particular the vertebrate fauna) by, among others, Meek and Hayden in 1855 (1856a and 1856b), Cope in 1876, Stanton and Hatcher in 1905, Sahni (1972), Case (1978a and 1979), Rogers (1994 and 1998), Rogers and Eberth (1996), and Rogers and Kidwell (2000). Extensive studies have been carried out to determine the age and relationship of the formation to others in the region. These studies have shown that the JRF is mostly nonmarine, with dominantly fluvial facies and local tidal influences. The formation is primarily composed of silty clays, siltstones, and fine-to-medium-grained sandstones.

The focus of this research is to examine the chondrichthyan fauna and geologic setting of the Woodhawk Bonebed (WH) and the Power Plant Ferry Bonebed (PPF) localities in the JRF. Hypotheses to be addressed include:

- Case's work (1978a and 1979) accurately reflects the Cretaceous diversity of sharks in the region particularly with respect to heterodonty, a complicating feature of elasmobranch teeth;

- the biogeographical relationships of the Late Cretaceous shark fauna from the JRF will show it to be a rather typical fauna when compared to contemporaneous faunas from other formations in western North America;
- the current faunal list (Case 1978a and 1979) of the JRF represents a rather typical fauna from a coastal, warm shallow marine environment, so the area has been sufficiently sampled to create a complete faunal picture and no undescribed taxa will be found;
- taphonomic factors have affected the composition of the chondrichthyan fauna;
- actualistic taphonomic experiments can be used to test the null hypothesis: there will be no significant difference between the teeth at the start of the experiment and at the end of the experiment;
- and actualistic taphonomic experiments can be used interpret the fossil material.

HISTORICAL BACKGROUND ON GEOLOGIC SETTING

The first scientific observation of rocks that would later be recognized as part of the Judith River area was by the Lewis and Clark expedition in 1804-1806 (Lewis, 1814) when they saw the white rocks (now named the Eagle Sandstone) in the valley of the Missouri River. Other early expeditions were carried out by the Prussian naturalist Alexander Philipp Maximilian, Prince of Wied-Neuwied as he travelled the Missouri River studying the Native Americans, wildlife, and strata (1839-1841); by Meek and Hayden (1856a and 1856b); by Hatcher (1903b), by Hatcher and Stanton (1903), and Stanton and Hatcher (1905). Almost from the outset, these Campanian aged sediments (Figure 2) have been objects of geological and paleontological study, including both invertebrates and vertebrates. The vertebrate fauna has been studied extensively, resulting in many enormous dinosaur skeletons now gracing the floors of major museums.

These early expeditions and other extensive studies by scientists including Meek and Hayden (1856a-b, 1857, and 1858), Hayden (1857, 1858, and 1860), Leidy (1856a), Cope (1874, 1876a-b, and 1877), C.H. Sternberg (1883, 1903, 1914, and 1915), Marsh (1888, 1889a-b, 1890, and 1892a-c), Brown (1907 and 1933a), and Matthew (1914) contributed to several efforts including the determination of the age of the JRF, the relationship of the JRF to other formations in the region, the correlation of formations across international boundaries, as well as the discovery and description of new fossil taxa.

1850s-1870s

The perceived age of the rocks, which were often referred to as the Judith River beds (Meek and Hayden, 1856b and Hayden, 1858) in the mid-1800s, ranged from Jurassic to the Tertiary (Meek and Hayden, 1856a-b) on the basis of the invertebrate fossils collected by Meek and Hayden in 1855 (1856a-b). In 1876 Cope confirmed Meek and Hayden's (1856a-b) views that the beds were Upper Cretaceous in age with his own studies and descriptions on vertebrate specimens collected from the area by Hayden in 1855 (Cope, 1874, 1876a, and 1877). This occurred after Cope (1869) had originally claimed a Jurassic age for the fossils. Cope (1876b) also surveyed the area himself with colleagues and collected specimens that he later published. Materials collected by Hayden were also examined and published by Leidy (1856a) who compared them to European Cretaceous specimens.

1880s-1900s

In addition to the aforementioned studies, research also focused on coeval deposits and fossils from Canada and Wyoming. These studies contributed to determining the age and geographic extent of the JRF. G.M. Dawson (1883 and 1884a-b) completed regional and fossil studies of the Bow and Belly River Formations in the Northwest Territory, while the plants were studied by J.W. Dawson (1886) who concluded that the Bow and Belly River Series and the Oldman River and Medicine Hat Formations were Jurasso-Cretaceous or lower Cretaceous in age. Whiteaves (1885) studied the invertebrates from the Belly River Group in Canada, finding many of the same fossils in the Belly River Series as Meek and Hayden found in the JRF. Whiteaves also made early correlations of formations in the U.S. and Canada. Vertebrate studies from the Belly River Group along with provisional stratigraphical correlations were carried out by Osborn (1902) and by Lambe (1902) who also worked on a shark fossil from Alberta (Lambe, 1918). Fossils from the Judith River beds, Lance Creek, and the Belly River beds were all compared to each other by Hatcher (1903a) who found sufficient taxonomic similarities among them to assign similar ages to the formations.

1900s-1940s

In 1903 Hatcher and Stanton surveyed the Judith River area, completing studies on the stratigraphy, invertebrates, vertebrates, and flora, and assigned an Upper Cretaceous age to the JRF (Stanton and Hatcher, 1905 and Knowlton, 1905). Brown (1907, 1908, 1911, 1912, 1913a-c, 1914a-e, and 1933a-b) conducted excavations and studies of material collected from Montana as well as the Cretaceous beds (along with some Eocene material) of Canada, notably Alberta, working on the stratigraphy and vertebrate paleontological faunas. Peale (1912a-c) worked on the age and the stratigraphic position of the JRF, followed by Stebinger (1914a-b) who traced the lithologic changes of the Montana Group (of which the JRF is a part of) northward. C.H. Sternberg (1914, 1915, 1916-1917, 1918) contributed with collections and studies on the Campanian vertebrates from the Belly River Series of Canada in addition to vertebrates from the JRF in Montana. C.H. Sternberg (1914 and 1918) noted that both the succession of rocks and vertebrate fossils in the Edmonton and Belly River Series appeared to be of the same type as seen in the JRF and deduced that the observations made by Hatcher and Stanton (1903), Stanton and Hatcher (1905) on stratigraphic correlations were correct (C.H.

Sternberg, 1915). Bowen's (1915) studies of the Montana Group in north-central Montana confirmed the work by Stanton and Hatcher (1905). Bowen (1915) suggested a Cretaceous age for the JRF and determined its stratigraphic position beneath the Bearpaw Shale and above the Claggett Formation based on lithology and faunal indicators. Bowen also found that many of the invertebrate and vertebrate fossils in the JRF correlated with those found in the Belly River Series. C.H. Sternberg's son (C.M. Sternberg) also collected many fossils from the Edmonton Formation of Alberta (C.M. Sternberg, 1926, 1928, and 1940a-b).

1940s-1980s

Russell and Landes' (1940) work on the Canadian stratigraphy and invertebrate paleontology of the southern Alberta Plains reviewed Dowling's (1917) study, and confirmed Bowen's (1915) work in the U.S.A. Stott (1963) reiterated Russell and Landes' (1940) findings. Cobban and Reeside (1952) completed broad sweeping correlations of the Cretaceous strata in the western interior of the U.S.A. in order to delineate age boundaries. Lerbekmo (1961) looked at stratigraphical relationships of the Milk River Formation and the Belly River Formation in southern Alberta, and Estes (1964 and 1969b-f), Estes and Berberian (1969 and 1970), Estes et al. (1969), and Sahni (1972) worked on vertebrate faunal analyses of the Cretaceous in Wyoming and Montana. Russell (1964) studied the non-marine fauna in Cretaceous rocks of northwestern North America; Langston (1965) compiled a survey and studied the history and pondered the potential future of vertebrate paleontology in Canada; Fox (1972) discovered a new genus of mammal, and Langston (1976) surveyed the vertebrate fauna of Alberta. In 1973 Gill and Cobban published their work on the paleogeography of the Upper Cretaceous of the Montana Group utilizing combined data from stratigraphy, paleontology, and radiometry. Wall and Rosene (1977) studied the Upper Cretaceous stratigraphy of the southern Alberta Foothills, Case's studies (1978a and 1979) dealt with the chondrichthyan fauna of the JRF in Montana, and Neuman et al. (1988) examined the freshwater fishes of the JRF in Alberta.

1990s-2000s

In more recent years Eberth et al. (1990) studied JRF stratigraphy and vertebrate paleontology in Saskatchewan in addition to proposing new guidelines for standardizing the stratigraphical nomenclature for the formation. Rogers (1994 and 1998) and Rogers and Eberth (1996) looked at tectonic and eustatic aspects of the JRF, as well as the marine sequences and discontinuities. LaRock et al. (2000a-b) studied the taphonomy of dinosaur bonebeds of the JRF in northeastern Montana, and Bergman and Eberth (1998), correlated, on a regional scale, the JRF in Alberta and Saskatchewan. Hamblin (1995) studied the plains of Alberta with a focus on the Judith River group. Siverson (1995) revisited Case (1978a) by revising some of his work when in the JRF and Rogers and Kidwell (2000) investigated the taphonomic relationships of discontinuity surfaces. Mammal studies of the JRF were carried out by Carrano et al. (1995 and 1997) and mammal paleoecology of the Judith River Group in Alberta was studied by Sankey et al. (1999). Blob et al. (2001) discovered a new fossil frog in Montana; and Sankey et al. (2002) completed diversity and variation studies on theropod and bird teeth from the JRF of Alberta, covering both the geology and paleontology of the JRF. All of these studies, over the past 160 years have led to a framework for understanding of northern Great Plains Late Cretaceous paleoecology and geology. The current study will be presented in the context of that framework.

ELASMOBRANCH SYSTEMATIC PROBLEMS AND TOOTH CHARACTERISTICS

Historical Observations of Shark Teeth

Elasmobranchs are polyphydont, producing and shedding teeth over the entire course of their lives. Owen (1866) is often credited with the first hypothesized description of the mode of tooth replacement in sharks. Teeth were thought to be replaced by,

> ...the whole phalanx of their numerous teeth is ever marching slowly forwards in rotatory progress over the alveolar border of the jaw, the teeth being successively cast off as they reach the outer margin, and new teeth rising from the mucuous membrane behind the rear rank of the phalanx (Owen, 1866: 383-384).

However, similar, older accounts are present in André (1784) and cited within André is an even earlier work by Gesner (1558). It was Gesner's early observations (1558) and later Steno's (1667) (Figure 3) observations of extant and fossil shark teeth that initially demonstrated the identity of what had been termed "tongue-stones" or *glossopetrae*. *Glossopetrae* were also called *Linguae Melitensis* or *Linguae S. Pauli*, the Germans used *Nattern-zungen* (adder's tongues) or *Schlangenzungen* (serpent's tongues). Other terms include *Maltesichen amuletten* and *Ilsien San Pawl* (Zammit-Maempel, 1975).

Beginning with the Middle Ages, people believed the fossil shark teeth or *glossopetrae*, were stones that fell from the sky, an idea proposed by early historians and naturalists, or that they were spontaneously generated from the rocks in which they were encased (Zammit-Maempel, 1975). Another idea was that they were the tongues of serpents that were turned to stone by Saint Paul thereby possessing medicinal properties, including the ability to counteract poisons (particularly the Miocene age shark's teeth from Malta) (Zammit-Maempel, 1975). These beliefs and ideas were most prevalent between the thirteenth and eighteenth centuries (Zammit-Maempel, 1975), observations by naturalists such as Gesner (1558) and Steno (1667) not withstanding.

Early observations and dissections of extant sharks led Steno (1667) to believe that teeth found inside (or within) the jaws were of little or no use to the animal. He also surmised that fossil shark teeth found in sediments were not *glossopetrae* but were instead shark teeth that had been altered.[*] However, it was demonstrated in the earlier work by Gesner (1558) that those posterior or "within the jaw" teeth did have a function; as the anterior or functional teeth wore away, broke, or fell out the posterior teeth would then move forward to fill in the spaces vacated by the previous anteriorly placed teeth. This was demonstrated by André (1784) when he observed a stingray tail spine bisecting teeth of a tiger shark (*Galeocerdo cuvier*). While not noted in the paper, his illustration (Figure 4) clearly shows that teeth are replaced. In order for the teeth to be bisected (teeth labelled "B" in the image) they had to form around the foreign body implanted in the tooth germ, which is seen in the functional tooth and in the replacement teeth. As shark jaws would not have foreign bodies implanted in them at the time of birth, the initial tooth or teeth would have been "normal" as is seen on either side of the bisected tooth in the image (teeth labelled "A" in the image). However, it seems that these early investigations were

[*]Steno's work (1667) became paramount and had great ramifications on the study of geology when he questioned the formation of solids within solids and also laid the foundations for the principles of stratigraphy.

lost as Owen (1866) is the most frequently cited work and subsequent scholars such as Cawston (1938, 1939a-b, 1940a-c, 1941a-d, 1944, and 1945) were not even convinced of Owen's postulations. This uncertainty of the tooth replacement was the status quo for a long time until researchers sought to validate Owen's hypothesis and determine the rate of tooth loss or shedding rate of sharks. Despite the studies (below), very little is still known about the shedding rate. It is presumed that the complete teeth, both fossil and modern, used in this study were fully formed functional teeth, having been preserved prior to any taphonomic factors influences acting on them.

Shedding Rates of Shark Teeth

Various approaches yielding mixed results have attempted to determine the rate of shedding of shark teeth. Breder (1942) observed that in *Carcharias littoralis* a loosened tooth took 2-7 days to detach, and that a single tooth was lost at a time with nothing to suggest the simultaneous loss of an entire row. This was contrary to studies by Cawston (1938, 1939a, 1940a-b, 1941a-d, and 1944) who insisted that the teeth were not replaced but instead grew continuously throughout life. Cawston's studies of teeth and of tooth replacement also extended to other fish and reptiles (1939b, 1940c, and 1945), and he also refuted tooth replacement in other groups of animals. To explain any tooth loss observed from deep-water fish housed in aquaria Cawston (1944) claimed tooth loss occurred because the fish had been moved to an artificial environment, stressing the animals. Cawston (1940a and 1944) suggested that there would be overcrowding of the jaw due to successively larger replacement teeth, therefore, replacement would not occur. However, that last argument is moot as Cawston reported that the teeth grew continuously, which would also lead to overcrowding in the jaw, by his reasoning. Cawston (1938) also rejected André's (1784) observations, saying that the bisection through the teeth of the tiger shark is a result of having had the teeth impaled by the spine and creating a tear as the shark tried to wrench itself free.

Ifft and Zinn (1948) were able to observe tooth replacement in sharks as originally hypothesized by Owen in 1866, i.e. teeth moving forward to the outer margin from the back. However, they were not able to deduce the normal rates of shedding as the sharks died prior to obtaining sufficient data. Despite the deaths, Ifft and Zinn were able to obtain initial rates, 10-12 days for one tooth row in the smooth dogfish (*Mustelus canis*), having observed that tooth buds were needed for tooth development and replacement and that they occurred behind the erupted teeth and no where else (1948).

During the 1960s the subject was revisited by Strasburg (1963), Tessman (1966), and Moss (1967). Strasburg's study was of a comparative nature in which relative rates were determined. The findings determined that rates were dependent on the species. Strasburg (1963) discovered that different species shed their teeth differently, including: singly, a few teeth at a time, most of the teeth in a tooth row, or whole tooth rows. Also discovered were differences between the top and bottom jaw. These factors were also noted by Peyer (1968), who observed that age and metabolic rate of the sharks could also be contributing factors. Also of interest is that the tooth arrangement in some species may prevent or block the replacement of other teeth (Strasburg, 1963). Strasburg noted five different tooth arrangements in shark jaws from his 1963 study: 1) no overlap (independent dentition), 2) alternate overlap, 3) imbricate overlap, 4) mixed alternate overlap, and 5) modified imbricate overlap, which occurs when the teeth of the right and left halves of the jaw are imbricated in opposite directions and the mesial tooth is in an alternate position with respect to its neighbors (Figure 5). Tessman (1966) estimated that a single tiger shark could produce 24,000 teeth in a 10 year period. However, this was not substantiated with observations or citations. Moss (1967) was able to corroborate Strasburg's work, finding different replacement rates in the lower versus upper jaw of the lemon shark (*Negaprion brevirostris*), with a faster rate in the upper jaw (1 tooth in 7.8 days) than the lower (1 tooth in 8.2 days). However, the difference in these rates is slight and may not be statistically significant. Moss (1972) also sought to relate the replacement rate to body growth and devised, through empirical means, a formula to estimate body growth rates based on tooth replacement measurements.

Luer et al. (1990) found that replacement rates were not dependent on body growth (during the duration of their experiment) but rather on water temperature, utilizing a tank that was in an open system with ambient seawater from the Gulf of Mexico subject to seasonal temperate changes. However, it should be noted that growth rate (and metabolic rate) can be influenced by temperature, therefore declaring there was "no correlation between growth rates and tooth replacement rates" likely incorrect. Luer et al. (1990) found that the nurse shark (*Ginglymostoma cirratum*) produced faster replacement rates at 9-12 days for a tooth row in warm water versus cold water rates at 51-70 days for a tooth row. They also noted that there seemed to be no particular order of shedding. Overstrom (1991) calculated rates of replacement at 0.48 teeth per day in captive sand tiger sharks (*Carcharias taurus*) but the work did not take age and growth rate into account.

Polyphydonty

Polyphydonty, and a high preservation potential, has led to an abundance of shark teeth in the fossil record; it is frequently noted that shark teeth are the most abundant benthic vertebrate fossil (Maisey, 1984). It should also be noted that because shedding rates are not universal and dependent on a whole host of factors (seasonality, feeding, tooth arrangement, etc.) it is not possible to estimate size of populations in a given fauna. Due to their great abundance, shark teeth have been used as the primary basis for identifying shark species. Also used but to a lesser degree are fin spines and dermal denticles. Centra and other preserved cartilaginous elements, items with comparatively low preservation potential can also be used. However, due to their abundance and availability, teeth have been the main source for species determination despite the problems they can pose.

When species determinations are dependent on teeth alone, problems arise due to the disassociated teeth that comprise from the fossil record. Many of these problems have arisen due to various forms of heterodonty (homodonty, the condition of all the teeth being of the same shape and size, is approximated by some shark and ray species; however, it is doubtful as to whether any shark or ray species is truly homodont according to Welton and Farish [1993]). Heterodonty is present in virtually every species, and must be considered, along with convergence, tooth type, tooth position, and tooth pathology, when dealing with elasmobranch teeth.

Heterodonty

Four different types of heterodonty exist in elasmobranchs. Monognathic heterodonty is change in tooth shape running mesiodistally along the jawline in either the upper or lower jaw (Figure 6). Dignathic heterodonty occurs when there are differences between the upper and lower jaws (Figure 7). Ontogenetic heterodonty occurs when teeth change shape throughout life as the shark or ray grows (Figure 8). Sexual heterodonty, although rare, refers to different tooth shapes in similar positions in females versus males of the same species (most often seen in certain groups of rays and largely dependent on diet) (Cappetta, 1987 and Peyer, 1968) (Figure 9). Failure to understand the role of heterodonty has led to problems with "splitting" and "lumping." Excessive splitting has the potential to create invalid species, giving the impression that there was more diversity than actually existed, while lumping may create a false picture of low species diversity.

These problems have persisted for as long as scientists have been describing new species, and have only been systematically addressed in recent studies (Siverson, 1992 and 1995 and Naylor and Marcus, 1994) but remain largely unresolved. Naylor and Marcus (1994) addressed heterodonty by studying 500 jaws from different species of *Carcharhinus* with the goal of using isolated teeth to identify carcharinid sharks to the species level. They found that teeth (whether isolated or still in place) from certain positions from either the lower or upper jaw of one side of the mouth appeared identical to teeth from the opposing jaw and side. For instance, the lower left teeth angle in the same manner as the teeth from the upper right (Naylor and Marcus, 1994). They also observed that different species within *Carcharhinus* vary in the number of tooth positions – this variation exists for both the upper and lower jaws, and also in the number of teeth contained in a tooth series within a species (Naylor and Marcus, 1994). To overcome these problems and identify isolated teeth to the species level in both fossil and extant species, Naylor and Marcus (1994) systematically and statistically analyzed the shape of the teeth. Their work is the first attempt to deal with heterodonty in shark teeth in a non-subjective manner.

Convergence

Convergence is another challenging aspect of shark taxonomy. Convergence occurs when a similar morphology develops in distantly related groups due to a similar way of life. A commonly cited example is the similarity of the external shape of sharks, dolphins, and ichthyosaurs. The same phenomenon occurs in chondrichthyan teeth. Cappetta (1974) suggested, for example, that there might be convergence in sclerorhynchid teeth, creating difficulties in identifying isolated teeth to species. His observation was stated without the support of a phylogenetic analysis, but it does illustrate the potential problem of convergence in elasmobranch teeth.

Tooth Type

Six primary tooth types occur in chondrichthyans according to Cappetta (1987): 1) clutching (typically exhibited by Orectolobiformes), 2) tearing (displayed by

Hybodontidae and Odontaspididae), 3) cutting which has two sub-types (cutting *sensu stricto*, seen in *Squalicorax* and other lamnids and cutting-clutching seen in the Lamnidae, Carcharhinidae, and Hemigaleidae), 4) crushing (Rajiformes and Dasyatidae), 5) grinding (found in Myliobatids), and 6) clutching-grinding (only seen in heterodontids).

Clutching-type dentition usually consists of small teeth with lateral cusplets that help hold prey (Figure 10). These teeth tend to be from small sharks that typically live near or at the bottom. Narrow cusps with lateral cusplets typify the tearing-type dentition, with trends towards the cutting-type dentition seen in the enlargement of the lateral teeth (Figure 11) (Cappetta, 1987). The cutting-type dentition displays monognathic and dignathic heterodonty in overall morphology with one functional row of usually serrated teeth that are labio-lingually flattened (Figures 12a-b). Cutting-clutching shows strong dignathic heterodonty with teeth becoming wider and flatter in the labio-lingual direction while retaining a high and narrow cusp in the anterior and anterolateral files (Figures 13a-c) (Cappetta, 1987). Crushing type dentition is usually seen in benthic forms, with narrowly imbricated teeth in many functional rows and files (Figure 14). Also seen in benthic taxa is the grinding type dentition, in which teeth are in multiple rows (in early forms, later forms show reduction in the number of rows), narrowly imbricated, with high polygonal crowns (Figure 15). The sixth type, clutching-grinding, has cuspidate anterior teeth that include lateral cusplets for clutching while the lateral teeth are flat and wide for grinding (Figure 16) (Cappetta, 1987).

The Woodhawk (WH) and Power Plant Ferry (PPF) faunas exhibit five of the six dentition types (the exception clutching-grinding type). Broken down by category, tooth types represented include, the Orectolobiformes displaying the clutching type, tearing type seen in the Odontaspididae, cutting type in the Anacoracidae, crushing type in the Rhinobatidae and Dasyatidae, and grinding type in the Hypsobatidae, and Callorhynchidae (a family in the chimaerids).

Tooth Position

Applegate (1965) normalized the terminology used to describe the position of shark teeth. His system is used today, for instance in Shimada's (2007) *Cretalamna appendiculata* reconstruction. Applegate (1965) built on previous work by Leriche (1905, 1910, and 1926) and White (1931) who introduced terms to designate tooth positions. They were little used until Applegate (1965) reintroduced them in order to standardize the vocabulary in the scientific community. The terms that Leriche (1905) coined and that are now widely used are: symphysaires (symphyseals), antérieures (anteriors), intermédiaires (intermediates), and latérales (laterals) (Figure 17). An additional term now widely used is posterior, which was introduced by Applegate (1965), to be used in place of "posteriors of the lateral series" or "posterior lateral teeth" as used by White (1931).

Tooth Characteristics

Elasmobranch teeth consist of an enameloid covered crown and the root. In sharks the crown usually forms a sharp point called the cusp with the very tip called the apex. The labial and lingual faces of the cusp meet to produce the sharp cutting edges. The enameloid on either side can be smooth or folded, sometimes creating plications or vertical ridges. One or more pairs of laterally positioned cusplets (or denticles) may be present on either side of the main central cusp. Cusplets tend to be less developed and smaller than the main cusp. The root may be flat and massive when viewed basally (typical of Orectolobiformes) or it may have long well-separated lobes (bilobed) with a lingual protuberance and a nutritive groove centrally located on the lingual surface (typical of e.g., the Odontaspididae) (Cappetta, 1987). The crown-root boundary is usually marked on the lingual surface by a narrow groove lacking enameloid called the neck or lingual furrow (Figure 18 for a depiction of standard tooth anatomical features).

Batoid (ray and skate) teeth differ from other elasmobranch teeth in possessing a largely crushing-type dentition. In general the globular crowns of ray teeth lack cusps (in Torpediniformes and males of the Rajiformes and Dasyatoidea cusps are present on the crowns) but instead bear a high crest (transverse crest) on the occlusal surface of the crown that separates the lingual face from the labial face (Cappetta, 1987). The enameloid can be either smooth or folded. Distinctions can be made between lingual and labial sides, e.g. the labial face is typically more convex in shape and usually contains foramina that the lingual face usually lacks. The lingual face of the crown may also have overlapping protrusions called uvulae and are named to indicate their location on the lingual face. The root may be bilobed, separated by the nutritive groove; in some taxa, multiple grooves are present. The crowns of rhinobatoid teeth are simpler and rather smooth, with possible crenulations on the lingual face (Figure 19 for depiction of batoid tooth anatomy).

Root Types

The root can have one of four different root types as originally laid out by Casier (1947a-c), who made distinctions based on the placement of the foramina and the characteristics of the nutritive groove. The four basic root types are: anaulacorhizous, hemiaulacorhizous, holaulacorhizous, and polyaulacorhizous (Figure 20). Anaulacorhizous roots are seen in primitive elasmobranchs such as hybodontoids and hexanchoids. These roots tend to be flattened and tabular, lack nutritive grooves, and are very porous. Hemiaulacorhizous roots are characterized by a broad triangular shape in basal view, with a large central foramen set in a shallow to deep depression. These roots first appeared in the Jurassic and are found in heterodontids, some orectolobiforms, and squatinids (Cappetta, 1987). Holaulacorhizous roots have a continuous well-developed nutritive groove that lies between mesial and distal root lobes. This root structure is seen in Lamniformes, Carcharhiniformes, and nearly all batoids (other than some Myliobatiformes) and is the predominant root type found in the faunas studied herein. Polyaulacorhizous roots are found on certain derived batoid teeth that are mesodistally expanded and have many labiolingually-oriented nutritive grooves. The root takes on a comb-like appearance and has many foramina that pierce each groove and the labial and lingual root faces. This structure is found on some of the more derived Myliobatiformes (Cappetta, 1987).

Tooth Histology

Elasmobranch teeth are composed of fluorapatite $Ca_5(PO_4)_3F$ in two calcified forms, dentine and enameloid. The dentine surrounds the pulp cavity and the enameloid (analogous to mammalian enamel) coats the outer surface of the crown (Halstead, 1974). There are two types of generalized dentine recognized --- trabecular dentine (Röse, 1897) (or osteodentine Ørvig [1951]), and orthodentine (Peyer, 1968). Elasmobranch teeth have been grouped into two distinct histologic tooth types, osteodont and orthodont (Figure 21). Osteodont teeth have trabecular dentine filling the core of the crown (no large pulp cavity) surrounded by orthodentine and covered by a thin layer of enameloid. Orthodont teeth have a crown with an enlarged pulp cavity surrounded by a thick trabecular dentine layer and an intermediate thin, orthodentine layer and outer superficial enameloid sheath (Welton and Farish, 1993). Elasmobranchs with osteodont histology include (most) Hybodontoidea, Hexanchiformes, Lamniformes, and Myliobatiformes. Orthodont histology is represented by the Squantiniformes, (most) Orectolobiformes, Squaliformes, Heterodontiformes, Carchariniformes, and (most) Rajiformes (Welton and Farish, 1993 and Cappetta, 1987).

Holocephalians

Holocephalians differ from other chondrichthyans in that they have tooth plates. They are composed of a crown and root like shark teeth however they are different in form and structure from the more typical chondrichthyans. The tooth plates grow slowly, and are not replaced (Stahl, 1999). Previous studies (Bigelow and Schroeder, 1953 and Peyer, 1968) incorrectly showed that there were only one or two pairs of upper tooth plates -- a smaller anterior plate (the palatine) and a larger posterior plate (the vomerine) -- and a pair of lower mandibular plates. There are usually two or three pairs of upper tooth plates -- a smaller anterior plate (the palatine) and a larger posterior plate (the vomerine) -- which are opposed by one, two or three pairs of lower mandibular plates (Stahl, 1999) (Figures 22a-c). These plates are complex, but a holocephalian tooth plate includes a lamellar tissue base (Stahl, 1999) on top of which sits a wide meshed system of trabecular dentine that contains interspersed odontoblast ball chains (sometimes called cosmine rods) (Peyer, 1968), recently described as orthotrabeculine (Stahl, 1999), and vascular channels. The vascular channels continue to the occlusal surface and create a punctuate pattern in the enamel (Stahl, 1999). The trabecular dentine is covered by a protective coating of vitrodentine or enamel (Peyer, 1968 and Stahl, 1999) (Figure 22d).

GEOLOGIC SETTING AND LOCALITIES

Montana Group

Bowen's (1915) work on the Montana Group is the most frequently cited study. The following brief description of the Montana Group and its formations largely draws on Bowen's work except where more recent research and revisions have been made, in those cases, the appropriate references have been utilized and cited in addition to Bowen (1915). The Montana Group, a term first proposed by Eldridge (1889), is composed of the Eagle, Claggett, Judith River, and Bearpaw formations (Sahni, 1972), which sits conformably atop the black laminated Colorado Shale.

Eagle Formation

The Eagle Formation (originally designated as the Eagle Sandstone by Weed, 1899) is marine to brackish water in origin (Hearn et al., 1964; Gill and Cobban, 1973; and Rogers, 1994) and is divided into a lower and an upper unit.

Lower - The lower member of the Eagle Formation is the Virgelle Sandstone Member (Bowen, 1915), a massive to heavy bedded sandstone that is largely unfossiliferous (Sahni, 1972). It consists of high angle planar cross-bedding, and in the northern exposures the coloration is white with rusty colored concretions. Southern exposures show a gray to light brown color with ledges or hogback ridges (Sternberg, 1914 and Bowen, 1915).

Upper - Northern exposures have thin-bedded sandstones with interbedded shales, and the middle member is a dark colored shale with a few thin beds of carbonaceous shale, coal, and sandstone. In southern areas the middle member has thin bedded shaly sandstones and lacks coal and carbonaceous beds (Bowen, 1915 and Hearn et al., 1964).

<u>Claggett Formation</u>

The Claggett Formation (named by Stanton and Hatcher, 1905) is also divided into a lower and an upper unit, which lie conformably on top of the Eagle Formation.

Lower - Largely a dark marine shale with many of the same invertebrate species as the Bearpaw Formation. Examples include: *Baculites ovaltus*, *B. compressus*, *Gervillia borealis*, *Inoceramus barabini*, and *Leda evansi* (which are also characteristic of the Pierre Shale) (Bowen, 1915 and Sahni, 1972). The Pierre Shale is marine in origin; it is a thick, fossiliferous shale that extends from North Dakota to New Mexico (Meek and Hayden, 1862).

Upper - Resembles the JRF in some places with alternating sandstone and shale beds that trend towards sandstone at the top (the unit may naturally belong to the JRF instead of the Claggett Formation due to the change in lithology and fossil fauna) (Bowen, 1915). Marine fossils are numerous (*Tancredia americana*, *Cardium speciosum*, *Mactra formosa*, and *M. alta*), many of which are characteristic of the Fox Hills sandstone (Hearn et al., 1964; Sahni, 1972; and Gill and Cobban, 1973).

<u>Judith River Formation</u>

The JRF is mostly nonmarine with a brackish to fresh water origin, having accumulated during the regression of the Claggett Sea and the transgression of the Bearpaw Sea (Hearn et al.; 1964; Sahni, 1972; and Rogers and Kidwell, 2000). It consists of alternating beds of sandstone (fine-to-medium-grained), clay (silty clays and siltstones) (Bowen, 1915), shale, and calcareous units that in combination with the fossils found (below) are characteristic of estuarine deposits (Hayden, 1860). Along the top of the unit in some places coal seams are present and the overlying members are marl and breccia (Hearn et al., 1964). It contains large numbers of the marine/brackish water habiting oyster *Ostrea*, bones of vertebrates, shark teeth, silicified wood, and leaf and stem fragments, which are found in vertebrate lag deposits in the discontinuities in the formation (Rogers and Kidwell, 2000).

Bearpaw Formation

The Bearpaw Formation (named by Stanton and Hatcher, 1905) is very similar to the Claggett Formation in lithology and the types of fossils found (Sahni, 1972). It is a dark green to black marine shale with calcareous concretions, and also contains portions of dominantly fissile bentonitic shale (Hearn et al., 1964). It contains many invertebrate fossils that are characteristic of the Pierre Shale (*Baculites ovaltus*, *B. compressus*, *Scaphites nodosus*, and *Inoceramus barabini*) (Sternberg, 1914 and Bowen, 1915).

Regional Correlations

Figure 23 shows a simplified stratigraphic section of Montana and correlative formations in southern Alberta.

The Eagle Formation (Upper Eagle Formation) of Montana grades into and correlates with the Upper Milk River Formation (or Milk River Group) in the Milk River area (east of Glacier National Park) (Johnson and Storer, 1974 and Sahni, 1972). The Milk River Formation (named by Dowling [1917] for its location on the Milk River) is a nonmarine deposit of light colored shales and sandstones with some dark gray argillaceous sandstone, sandy clay, and sandstone (Dowling, 1917 and Johnson and Storer, 1974).

The Claggett Formation (named by Dowling, 1915) is equivalent to the Pakowki Formation (Milk River area) in Alberta, similar both lithologically and faunistically (Sahni, 1972). The Claggett is marine in origin with a sequence of dark gray to dark brown shales, gray to brown to gray-green sandstones, and chert pebbles at the base (Dowling, 1917 and Johnson and Storer, 1974).

The lower unit of the JRF correlates with the Foremost Formation in the Medicine Hat area (Dowling, 1915). It is nonmarine, a mixture of shale, carbonaceous shale, siltstone, sandstone, and some ironstone and coal (Dowling, 1917, Sahni, 1972, and Hamblin, 1995). The upper unit has been correlated with the Oldman Formation (named by Russell and Landes, 1940) in the Medicine Hat and Dinosaur Provincial Park areas. This formation is also nonmarine and consists of bentonitic shale, carbonaceous shale, siltstones, and some limestone beds (Dowling, 1917; Sahni, 1972; Johnson and Storer, 1974; and Eberth et al., 1990).

The Bearpaw Formation continues into Alberta and is a dark brown sandy shale to dark gray shale, and argillaceous sandstone with some bentonites (Dowling, 1917; Johnson and Storer, 1974; and Eberth et al., 1990).

JRF Type Locality and Nomenclatural Problems

The JRF was named the Judith River Group by Hayden (1871) however, the type locality was not designated by Hayden (Bowen, 1915). Instead the locality was chosen by Bowen (1915) based on Hayden's descriptions in 1860,

> Near the mouth of the Judith River, not far from the sources of the Missouri, in latitude 47 ½°, longitude 109 ½°, is a wild, desolate, and rugged region, which I called the 'Badlands of the Judith' (Hayden, 1860: 123).

In addition to problems with defining the type locality, there have been problems with proper nomenclature for the formation and its included members, especially across international boundaries. Originally named the Judith Group (Hayden, 1860), it has also been referred to as the Judith River group, the Judith River beds and the Judith River Formation. Problems still existed into the mid-1900s in Canada, until Russell and Landes (1940) addressed the problem by trying to institute a uniform terminology by referring back to Dowling's (1917) work that they interpreted to be correct. Dowling redefined the stratigraphy of the Belly River Series originally laid out by Dawson (1884a) by teasing out differentiated beds, in descending order the Pale beds (later to become the Oldman Formation), Foremost, Pakowki, and Milk formations. More recently Eberth et al. (1990), standardized the terms within Canada and across the border.

Judith River Formation (JRF)

The JRF in Montana (also found extensively in Alberta as previously mentioned and in Saskatchewan) is Upper Cretaceous (Campanian) in age. It is mostly nonmarine, with dominantly fluvial facies with local tidal influences and primarily composed of silty clays, siltstones, and fine-to-medium-grained sandstones. The formation accumulated during the regressive and transgressive sequences of the Claggett Sea (regressive sequence 8 [R8]; see Figure 1 in Rogers and Kidwell, 2000) and Bearpaw Sea (transgressive sequence 9 [T9]; Figure 1 in Rogers and Kidwell, 2000), respectively, and is bounded above and below by the marine shales of the Claggett and Bearpaw formations (Hamblin, 1995 and Rogers and Kidwell, 2000). The JRF contains a number of discontinuities, within both the large-scale and small-scale regressive and transgressive sequences. The majority of fossils occur within the smaller scale, or minor, discontinuities, which are primarily represented by shallow marine sandstones. Fossils utilized in this study were collected from two of those discontinuities, D3 (Rogers, personal communication and personal observation) (Figure 1 from Rogers and Kidwell, 2000).

Localities

The teeth examined in this study were collected from the Woodhawk Bonebed (WH) (located at N 47° 44', W 108° 57') (Figure 24) and the Power Plant Ferry Bonebed (PPF) (Figure 25) (located at N 47° 43', W 108° 56'),* both within the Judith River Formation (JRF) (Figure 26). The bonebeds are developed on a widespread discontinuity surface located on the right bank of the Missouri River. The WH consists of two concentrated pockets of fossil debris (an upper scour and a lower scour) each of approximately 1 meter in lateral extent that crop out at the surface and has been previously interpreted to

*Precise coordinates are kept on file at the Science Museum of Minnesota.

coincide with a sequence boundary (Rogers, personal communication) while the PPF is one scour of approximately 1 meter in lateral extent. These bonebeds are very fossiliferous pockets that are part of a larger fossil-bearing horizon that spans tens of square miles in the eastern part of the Missouri Breaks (Rogers, personal communication) and are the same horizon and equivalent in age to the deposits in Blaine County that Case collected from in the late 1970s.

The WH is 2-4 centimeters thick (lower scour), and approximately 1-2 centimeters thick (upper scour), and the PPF is ~10 centimeters thick. The bonebeds are primarily composed of very well-sorted, moderately rounded, medium to fine-grained, yellow-tan shoreface quartz sandstone with traces of feldspar and even smaller amounts of pyroxene/amphibole (Rogers, personal communication and personal observation). In addition to vertebrate fossils, invertebrates are plentiful, including the oyster *Ostrea* (Rogers and Kidwell, 2000), and many marine trace fossils are also found, among them *Teichichnus*, *Ophiomorpha*, and *Skolithos* (Rogers, personal communication). Recent radiometric dates of nearby bentonite beds above (74 Ma) and below (75.4 Ma) place the bonebeds at ca. 74.5 Ma (Rogers, Kidwell, and Deino, in preparation).

REVIEW OF EARLIER JRF SHARK FAUNA STUDIES

The most recent comprehensive study on the chondrichthyan fauna of the JRF in Montana was completed by Case in 1978 (prior to that Sahni's work in 1972 concentrated on the terrestrial fauna - the only chondrichthyan he noted was *Myledaphus bipartitus*). Case (1978a) described 3 new genera and 12 new species of chondrichthyans. The new species described by Case (1978a) were: *Hybodus montanensis*, *Hybodus storeri*, *Synechodus andersoni*, *Synechodus striatus*, *Eucrossorhinus microcuspidatus*, *Cretorectolobus olsoni*, *Hypotodus grandis*, *Odontaspis sanguinei*, *Archaeotriakis rochelleae*, *Protoplatyrhina renae*, *Ischyrhiza* sp. (according to Case, a possible new species), and *Ptychotrygon blainensis*, in addition to a new orectolobid, *Chiloscyllium missouriensis*, and a chimaerid *Ischyodus bifurcatus* Case, 1978b. These were in addition to previously named taxa also collected by Case at this time (Case 1978a): *Squalicorax kaupi* Agassiz, 1843, *Archaeolamna kopingensis* (Davis, 1890), *Ischyrhiza* cf. [sic] *avonicola* Estes, 1964, *Ischyrhiza mira* Leidy, 1856b, *Myledaphus bipartitus* Cope, 1876a, and lastly a chimaerid similar to one named by Agassiz, *Elasmodus* cf. [sic] *greenoughi* Agassiz, 1843 (Case, 1979). Case identified all of these species primarily on the basis of isolated shark teeth, but also occasionally utilized dorsal fin spines, dermal denticles, and centra in conjunction with the teeth.

This current study includes previously known species from the JRF, such as *Hybodus montanensis*, *Cretorectolobus olsoni*, *Squalicorax kaupi*, *Squalicorax* sp., cf. *S. kaupi*, *Hypotodus grandis*, *Hypotodus* spp., *Archaeolamna kopingensis*, *Archaeotriakis rochelleae*, *Protoplatyrhina renae*, *Ischyrhiza mira*, *Myledaphus bipartitus* and a chimaerid, *Ischyodus* sp. The study also adds six additional species to the previous known diversity from the JRF, namely *Squalicorax pristodontus*, *Cretolamna appendiculata*, *Protolamna sokolovi*, *Ischyrhiza avonicol*a, *Ptychotrygon hooveri*, and *Ptychotrygon triangularis*, as well as additional taxa not identified to species such as *Squatirhina* sp., or, in some cases even to genus levels (Table 1).

METHODOLOGY

Field Methods

Roughly 21 kilograms of fossiliferous matrix was collected from the WH site by Dr. Raymond Rogers (RRR) (Macalester College) in August 2002, and approximately 45 kilograms of fossiliferous matrix was collected from the PPF site by the author in 2006 from Fergus County in north-central Montana. Prior to the 2002 bulk sampling RRR screen washed (with standard window screen mesh) sediments from the WH (creating a noticeable sampling bias where only the larger fossils were collected) with the resulting material included in this study. The matrix was later transferred to Michigan State University (MSU) for the purposes of this study.

Laboratory Methods

The matrix is loose, unconsolidated, free flowing material, and was dry-sieved (US standard mesh sieves [ASTM specification E-11], 4.75 millimeter to 0.037 millimeters) according to the methods outlined in Rixon (1976) in order to extract any shark and ray teeth, centra, and other fossils (such as teleost remains). Most fossil material was found in the 4.75 millimeter to 0.500 millimeter mesh sizes. Once sieved, the shark and ray teeth were cleaned of any excess matrix with a pin vice when possible and identified with the aid of the current literature utilizing both primary and secondary sources such as Case (1978a), Cappetta and Case (1975a), Case (1987), Meyer (1974), and identification guides by Kent (1994) and Welton and Farish (1993). All specimens were assigned catalogue numbers from the Science Museum of Minnesota (SMM) (SMM P2003:8:1-SMM P2003:8:28 [Woodhawk material collected in 2002 by RRR]; SMM P99:81:1-

SMM P99:81:17 [screenwashed Woodhawk material collected by RRR prior to 2002]; SMM P2006:13:1-SMM P2006:13:34 [Power Plant Ferry material collected by the author in 2005 and 2006]; and SMM P2006:15:1:1 (A1)-SMM P2006:15:8:4 (H4) [extant material for taphonomy experiments in 2005-2006]). The material will be reposited at the SMM after the study is complete. Specimen numbers were assigned in lots, with referenced specimens assigned special SMM specimen numbers. Illustrations of the specimens were made utilizing a Leica MZ8 stereozoom binocular microscope with camera lucida attachment, in addition to images generated from a JEOL 6400 SEM at the MSU Center for Advanced Microscopy.

Experimental Methods

The taphonomic experimental portion of this project will be discussed in the taphonomy section.

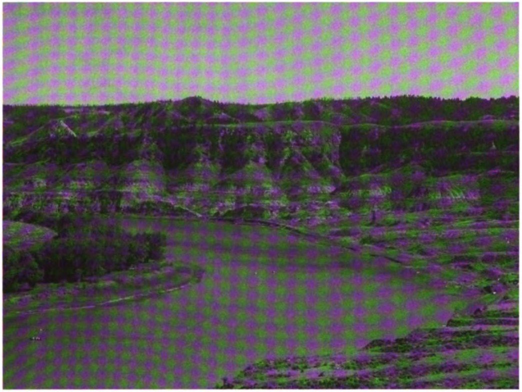


Figure 1. General view of Cretaceous badland topography (with the Missouri River in the foreground), Fergus County, Montana.

Figure 2. Campanian sediment outcrops in Montana, Wyoming, Alberta, and Saskatchewan. Star marks general area of research (modified from Sahni, 1972).

Figure 3. Shark teeth as originally illustrated by Steno (modified from Steno, 1667).

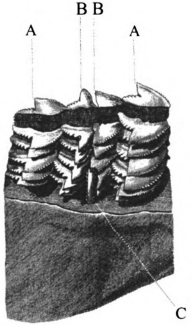


Figure 4. Lower jaw section of *Galeocerdo cuvier* from André (modified from André, 1784) where A represents "normal" teeth, B the bisected teeth, and C the stingray tail spine bisecting the teeth.

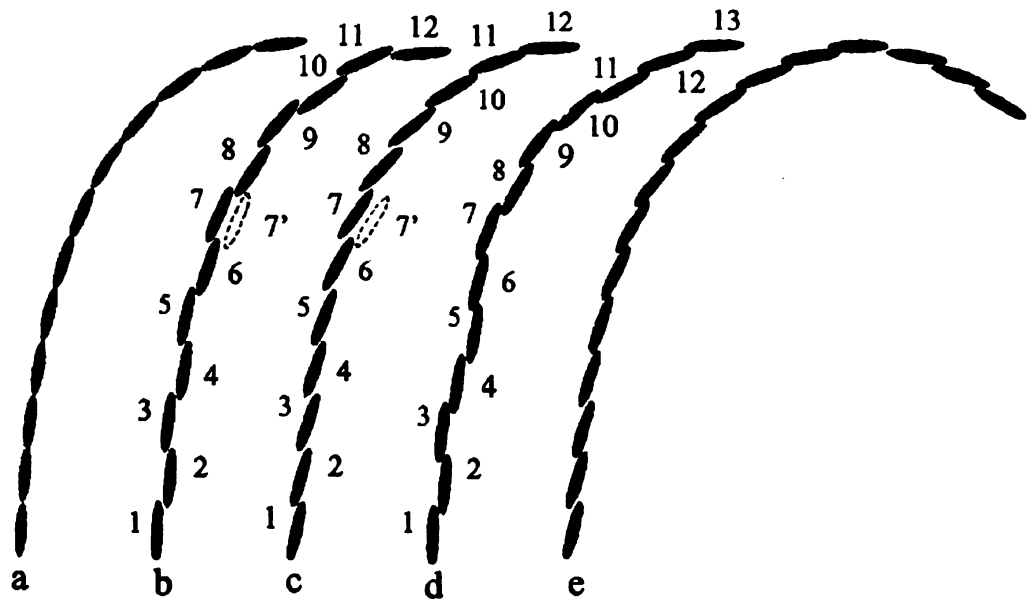


Figure 5. Tooth arrangements as identified by Strasburg (modified from Strasburg, 1963): a. no overlap (independent dentition), b. alternate overlap, c. imbricate overlap, d. mixed alternate overlap, and e. modified imbricate overlap.

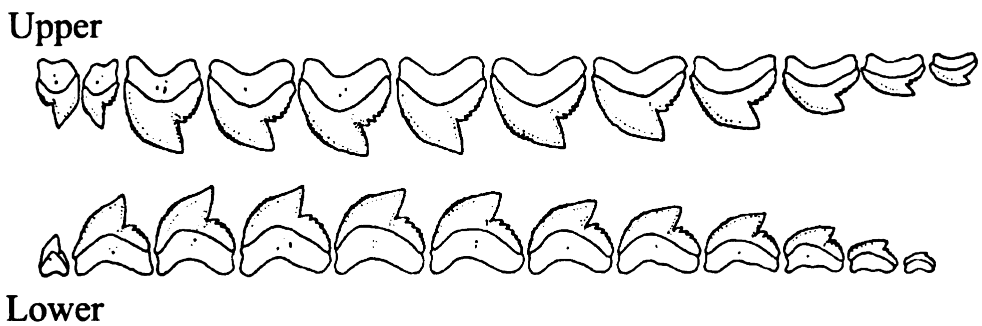


Figure 6. Jawline of Monognathic Heterodonty as seen in the modern tiger shark *Galeocerdo cuvier* (modified from Welton and Farish, 1993).

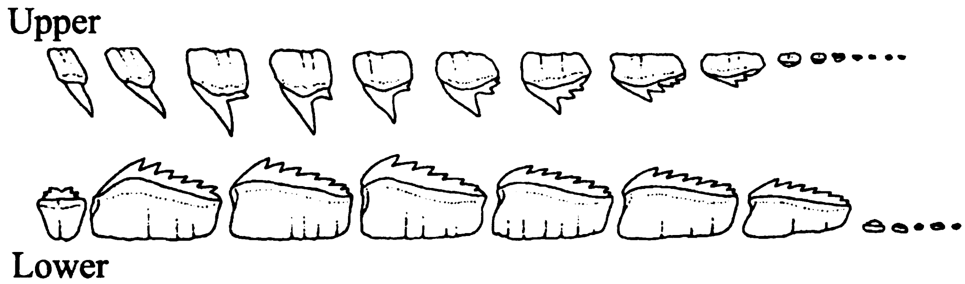


Figure 7. Jawline of Dignathic Heterodonty as seen in the modern sixgill shark *Hexanchus griseus* (modified from Welton and Farish, 1993).

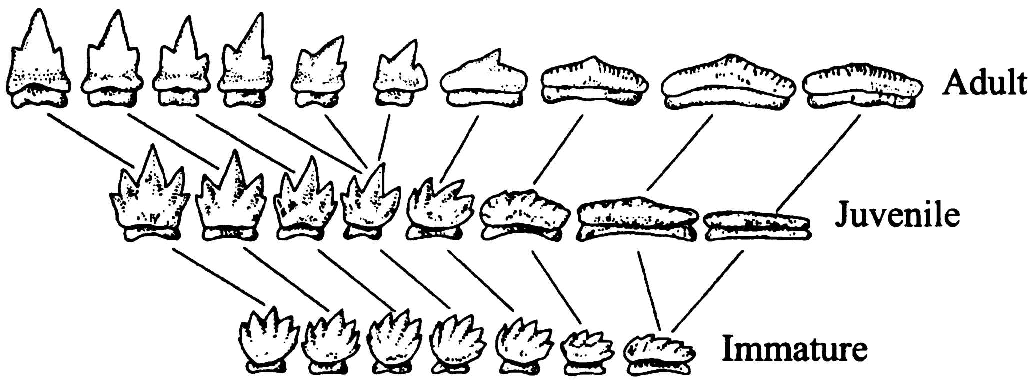


Figure 8. Jawlines of Ontogenetic Heterodonty as seen in the modern horn shark *Heterodontus franciscanus* (modified from Welton and Farish, 1993).

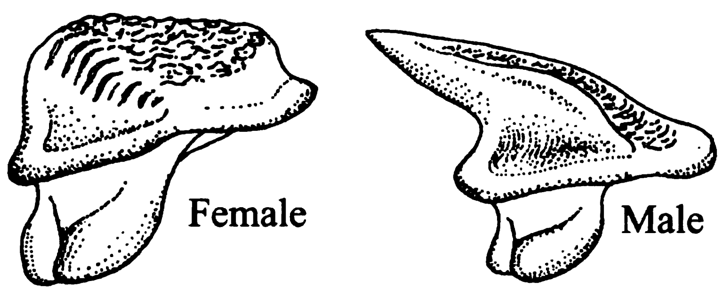


Figure 9. Sexual Dental Heterodonty as seen in the genus *Dasyatis* (modified from Welton and Farish, 1993).

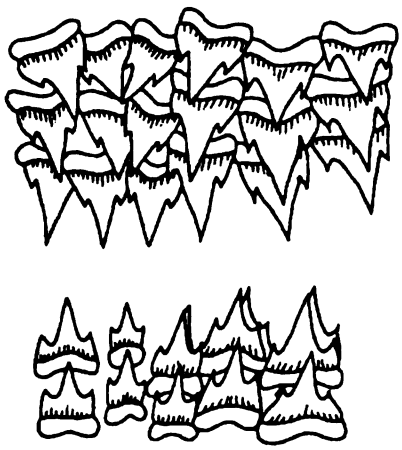


Figure 10. Clutching-type dentition exhibited by *Scyliorhinus retifer* (modified from Cappetta, 1987).

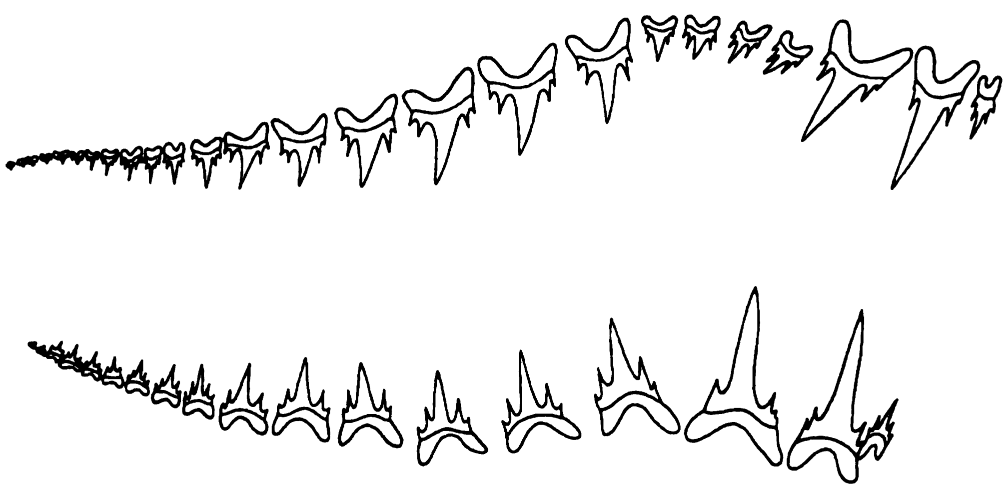


Figure 11. Tearing-type dentition seen in *Odontaspis ferox* (from Cappetta, 1987).

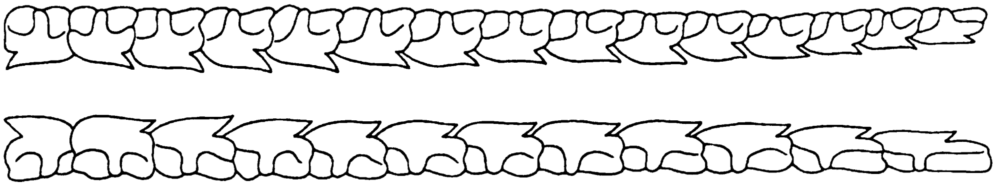


Figure 12a. Cutting-type dentition where cutting-edges are complete in *Squalus acanthias* (modified from Cappetta, 1987).

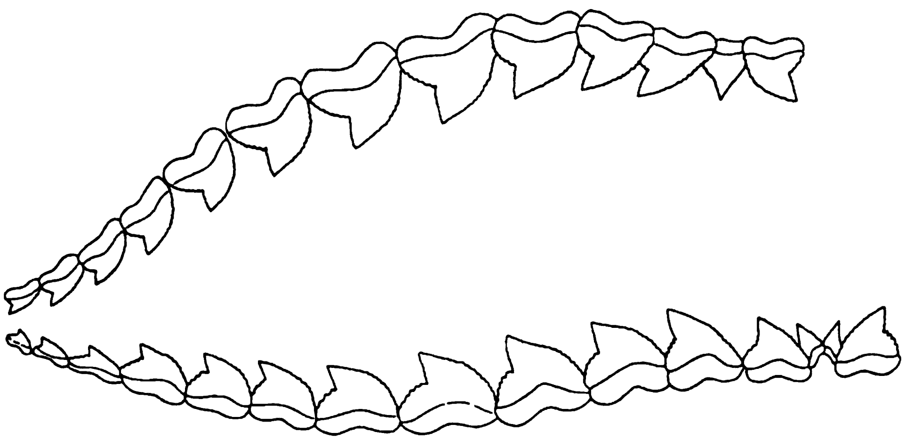


Figure 12b. Cutting-type dentition where cutting-edges are serrated shown in *Galeocerdo cuvier* (from Cappetta, 1987).

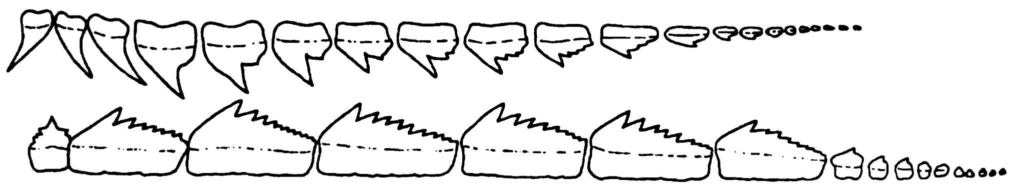


Figure 13a. Variation of cutting-clutching sub-type dentition as exhibited by *Hexanchus griesus* (modified from Cappetta, 1987).

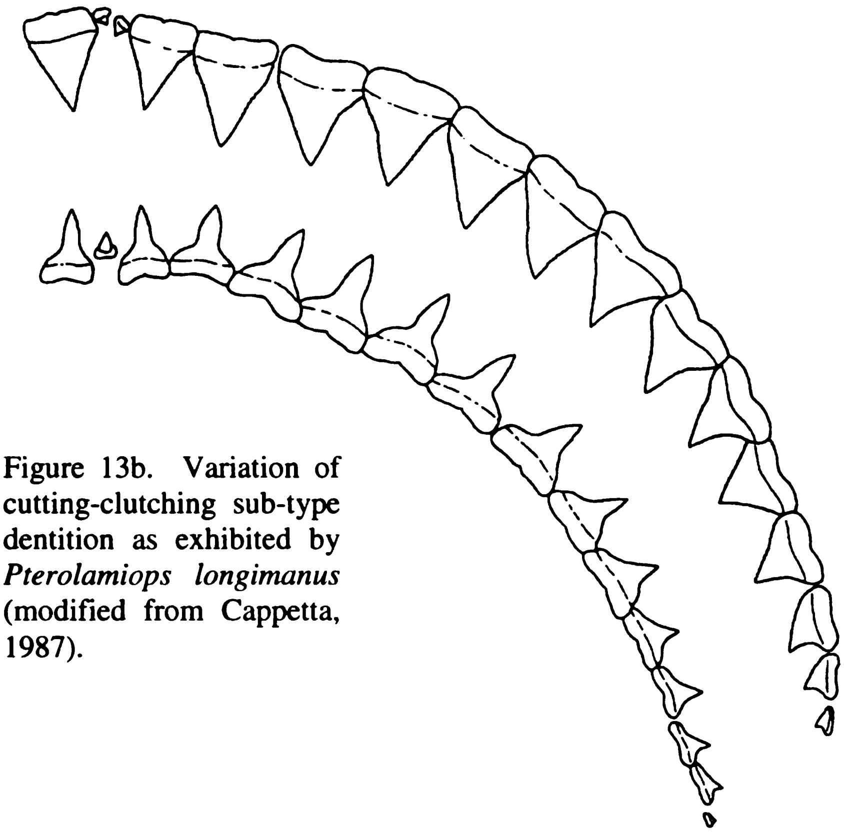


Figure 13b. Variation of cutting-clutching sub-type dentition as exhibited by *Pterolamiops longimanus* (modified from Cappetta, 1987).

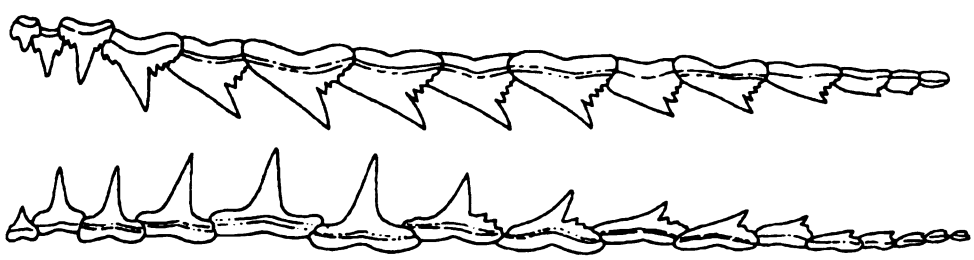


Figure 13c. Variation of cutting-clutching sub-type dentition as exhibited by *Paragaleus pectoralis* (modified from Cappetta, 1987).

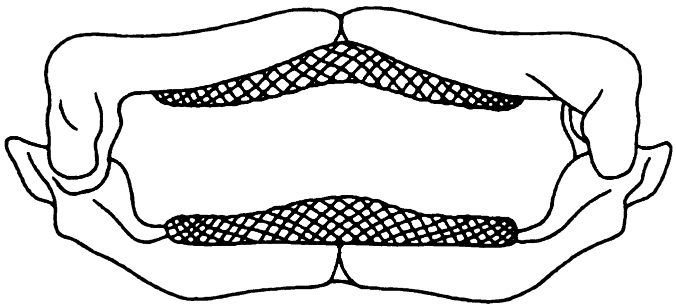


Figure 14. Crushing-type dentition displayed by *Raja clavata* (from Cappetta, 1987).

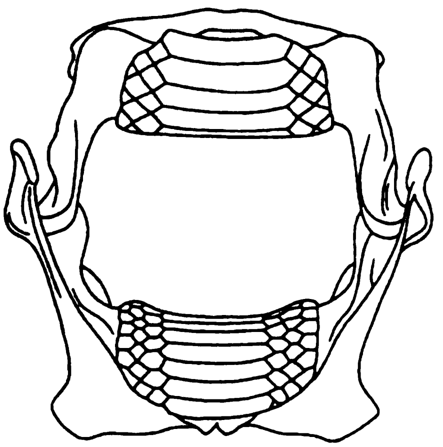


Figure 15. Grinding-type dentition shown in *Myliobatis* (from Cappetta, 1987).

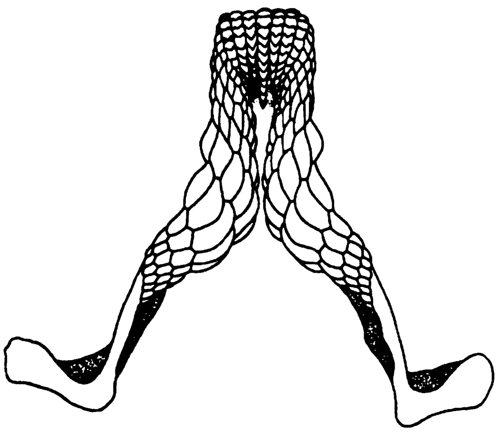


Figure 16. Clutching-grinding type dentition in *Heterodontus* (from Cappetta, 1987).

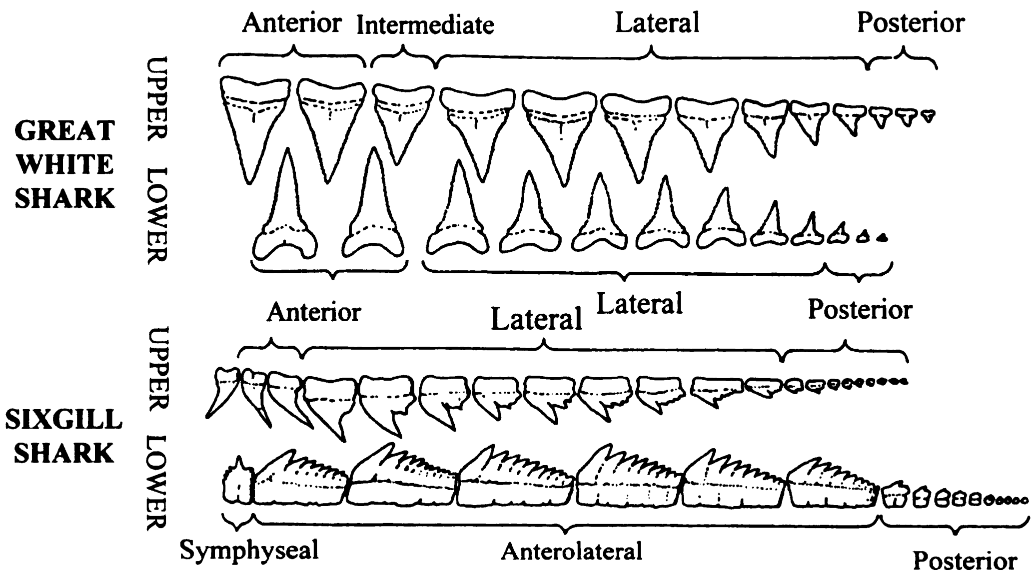


Figure 17. Tooth position terminology (left side of jaw) for the Great White and sixgill sharks (modified from Perry, 1994).

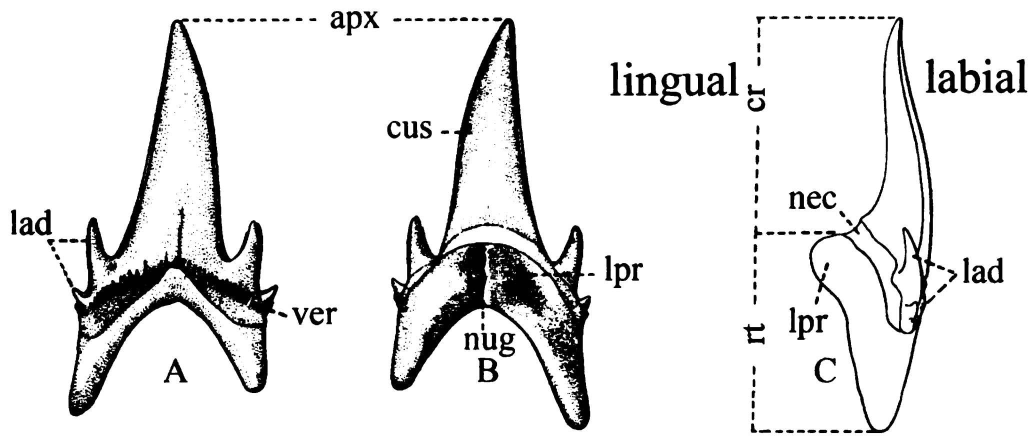


Figure 18. Tooth terminology of sharks: a. labial view, b. lingual view, and c. mesial view from anterior tooth of *Palaeohypotodus rutoti* (modified from Cappetta, 1987).

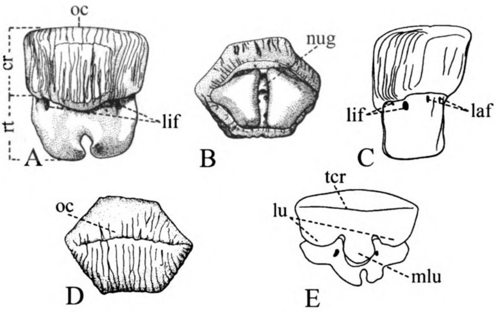


Figure 19. Tooth terminology of rays: a. lingual view, b. basal view, c. profile, d. occlusal view, from *Myledaphus bipartitus*; e. occlusal view from female lateral tooth of *Platyrhina sinensis* (modified from Cappetta, 1987).

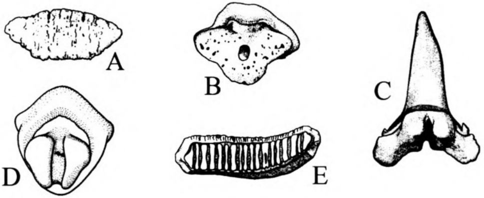


Figure 20. Stages of root vascularization: a. anaulacorhize stage (*Sphenodus* sp.), b. hemiaulacorhize stage (*Nebrius*), c. holaulacorhize stage (*Chaenogaleus*), d. holaulacorhize stage (*Raja*), and e. polyaulacorhize stage (*Igdabatis*) (modified from Cappetta, 1987).

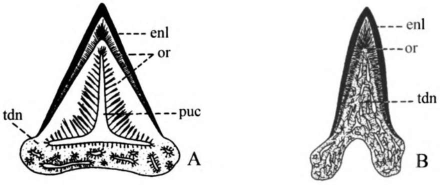


Figure 21. Histology of elasmobranch teeth: a. orthodont type (*Carcharhinus*) and b. osteodont type (*Lamna*) (modified from Cappetta, 1987).

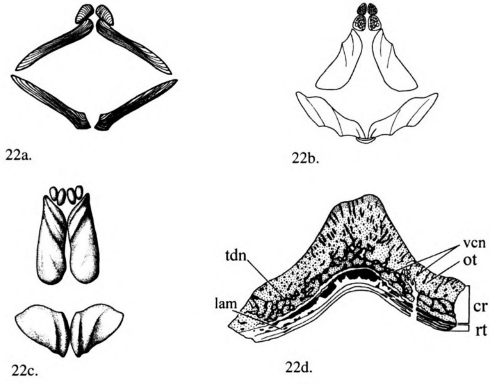


Figure 22. Examples of holocephalian tooth plate dentitions: a. *Squaloraja polyspondyla*, b. *Myriacanthus paradoxus*, and c. *Deltoptychius armigerus* (from Patterson, 1965); d. diagram of section through the long axis (mesiodistal) of *Helodus* tooth plate depicting tissues, root, and crown (modified from Stahl, 1999).

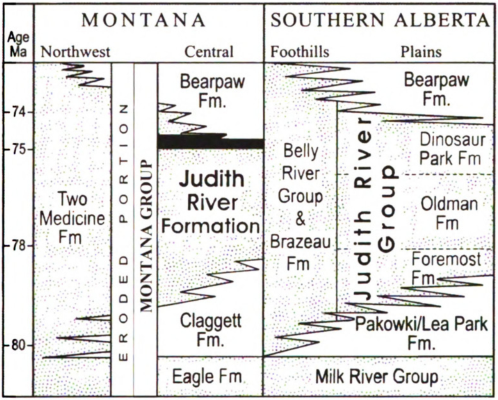


Figure 23. Generalized stratigraphic section of the Montana Group in Montana and southern Alberta (Judith River Group). Black band through the Judith River Formation represents the approximate position of the Woodhawk Bonebed and the Power Plant Ferry Bonebed in north-central Montana (modified from Sankey et al., 2002).

Figure 24. Close-up photo of the Woodhawk Bonebed, arrow marks bottom boundary of scour (Photo courtesy of R.R. Rogers).

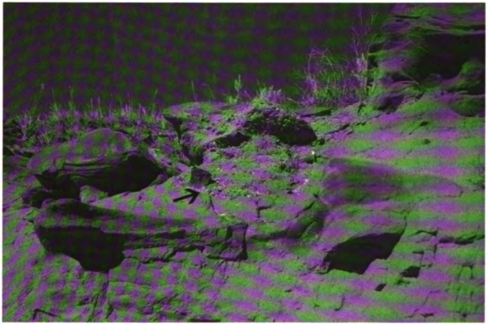


Figure 25. Close-up photo of the Power Plant Ferry Bonebed, arrow marks bottom boundary of scour (Photo courtesy of R.R. Rogers).

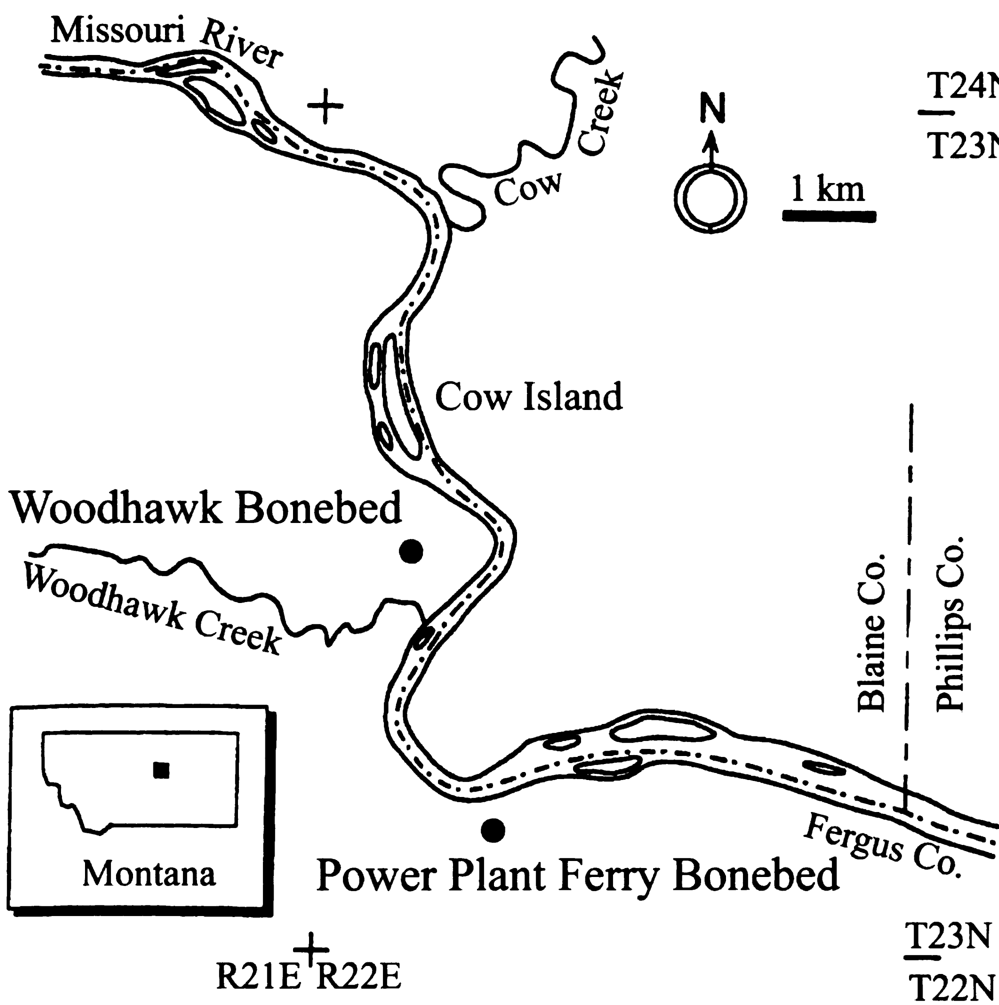


Figure 26. Map of sampling localities, Woodhawk Bonebed between Woodhawk Creek and the Missouri River, and Power Plant Ferry Bonebed adjacent to the Missouri River, Fergus County, Montana (modified from Blob et al., 2001).

	Sahni	Case	Tulu (WH and PPF)
Hybodus montanensis		x	x
Hybodus storeri		x	
Synechodus andersoni		x	
Synechodus striatus		x	
Chiloscyllium missouriensis		x	
Cretorectolobus olsoni		x	x
Squalicorax kaupi		x	x
Squalicorax sp., cf. S. kaupi			x
Squalicorax pristodontus			**X**
Eucrossorhinus microcuspidatus		x	
Hypotodus grandis		x	x
Hypotodus spp.			x
Odontaspis sanguinei		x	
Archaeolamna kopingensis		x	x
Cretolamna appendiculata			**X**
Protolamna sokolovi			**X**
Archaeotriakis rochelleae		x	x
Protoplatyrhina renae		x	x
Squatirhina sp.			**X**
Ischyrhiza avonicola			**X**
Ischyrhiza cf. avonicola		x	
Ischyrhiza mira		x	x
Ischyrhiza sp.		x	
Ptychotrygon blainensis		x	
Ptychotrygon hooveri			**X**
Ptychotrygon triangularis			**X**
Sclerorhynchidae indet.			x
Myledaphus bipartitus	x	x	x
Ischyodus bifurcatus		x	
Ischyodus			x
Elasmodus cf. greenoughi		x	

Table 1. Chondrichthyan fauna of the JRF. Data from Sahni, 1972, Case, 1978a and 1979, and present study. "**X**" in large bold represent new taxa found in the JRF, six confirmed species and one genus.

CHAPTER TWO

VERTEBRATE PALEONTOLOGY

Systematic analysis of the chondrichthyan fossils show that the material recovered is largely composed of lamniforms and rajiforms. Other representatives include: a hybodont, an orectolobiform, a carcharhiniform, a myliobatiform, and a chimaeriform. Additional material (teleost and crocodyliform teeth) is also briefly described.

Systematic Paleontology

The following taxonomic hierarchy for Elasmobranchii largely follows Cappetta (1987) except where recent revisions have been made; in those cases, the appropriate references are mentioned in the discussion of the taxon and the problematic nature of classification. Subterbranchialia hierarchy follows Stahl (1999) and Stahl and Chatterjee (2002), Teleostei follows Arratia (1999), and dental terminologies used in the descriptions below, follow the examples set by Leriche (1905, 1910, and 1926), Casier (1947a-c), Peyer (1968), and Applegate (1965).

Class CHONDRICHTHYES Huxley, 1880
Subclass ELASMOBRANCHII Bonaparte, 1838
Cohort EUSELACHII Hay, 1902
Superfamily HYBODONTOIDEA Zangerl, 1981
Family HYBODONTIDAE Owen, 1846
Genus *HYBODUS* Agassiz, 1837
HYBODUS MONTANENSIS Case, 1978a
Figures 27a-c

Material – Judith River Formation, Woodhawk Bonebed: lot and individual tooth, SMM P2003:8:6:1 and SMM P2003:8:6:2. 10 teeth/pieces.

Description – Case's (1978a) diagnosis for this species specifies teeth of medium to large size with a root width ranging from 5.0 mm to 20.0 mm, with plications at the enameloid border and up along the crown. There is one main cusp and lateral cusplets that are one third of the height of the main cusp. Nutritive pits and foramina can be observed below the root shelf on some specimens. Specimens collected from the WH are all partials with most of them being fragmentary. The best example from the WH (Figure 27a-c) is approximately 12.5 mm wide and contains the main cusp and has two complete lateral cusplets and one partial cusplet. The root structure is anaulacorhizous with osteodont histology.

Discussion – Very few complete specimens are known; most lack roots, and/or tips to cusps. Age and distribution is from the JRF, Campanian, Upper Cretaceous Montana, U.S.A. (Cappetta, 1987). Also occurs in the Teapot Sandstone Member, "Mesaverde"* Formation, Upper Campanian, Wyoming (Case, 1987), the Dinosaur Park Formation, Upper Campanian Alberta, Canada (Beavan and Russell, 1999), and the Black Creek Formation, Campanian, North Carolina (Robb, 1989). The genus *Hybodus* is found from middle Triassic to Late Cretaceous in North America, Europe, Asia, and north and west Africa.

Cohort NEOSELACHII Compagno, 1977
Order ORECTOLOBIFORMES Applegate, 1974
Family ORECTOLOBIDAE Gill, 1895
Genus *CRETORECTOLOBUS* Case, 1978a

*Mesaverde when referred to in Wyoming is placed within quotation marks to differentiate it from the type section of the formation in southwestern Colorado (the usage of the term Mesaverde Formation is used incorrectly in Wyoming) (Lillegraven and McKenna, 1986).

CRETORECTOLOBUS OLSONI Case, 1978a
Figures 28a-g

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:10:1, SMM P2003:8:10:2 (gold coated), SMM P2003:8:10:3 (gold coated), SMM P2003:8:10:4, SMM P2003:8:10:5. 67 teeth. SMM P99:81:3. 13 teeth. Power Plant Ferry Bonebed: lot SMM P2006:13:10. 8 teeth.

Description – Case's (1978a) diagnosis for this genus and species specifies teeth of small to medium size with a root width ranging from 2.0 mm to 8.0 mm and with a low crown and cusp directed towards the interior of the jaw, and appearing rather squatinoid in overall shape with a short broad cusp that tapers to a narrow apex. Labial flanges are short to long and narrow. Foramina can be present on the lingual surface below the overhanging uvula. Also present is a partially opened furrow (root structure is holaulacorhizous) on the rectangular or triangular basal surface of the teeth (Case, 1978a and Cappetta, 1987). Most of the specimens collected are complete with cusp, are approximately 5.0 mm wide, and do not clearly demonstrate the foramina. Foramina may possibly be obscured by matrix that was irremovable. Histology is orthodont.

Discussion – Siverson (1995) visited and collected specimens from Case's localities in Montana and Wyoming and made the conclusion that some of the teeth labelled *Cretorectolobus olsoni* Case, 1978a and *Eucrossorhinus microcuspidatus* Case, 1978a represent juvenile and adult forms of one species. He has also erected a new genus, *Cederstroemia* with two new species, *C. nilsi* and *C. triangulata* based on the specimens he collected. It is Siverson's contention that the teeth collected by Case were a mixture of *Cretorectolobus* and *Cederstroemia*. However, the teeth are so similar that the possibility exists that these teeth represent normal variation in a single species.

Age and distribution is from the JRF, Campanian, Upper Cretaceous Montana, U.S.A. (Cappetta, 1987) to the Kemp Formation, Upper Maastrichtian Texas (Case and Cappetta, 1997). Occurs also in the Teapot Sandstone Member, "Mesaverde" Formation, Upper Campanian, Wyoming (Case, 1987), the Dinosaur Park Formation, Upper Campanian Alberta, Canada (Beavan and Russell, 1999), and the Albian of France (Biddle, 1993).

Order LAMNIFORMES Berg, 1958
Family ANACORACIDAE Casier, 1947b
Genus *SQUALICORAX* Whitley, 1939
SQUALICORAX KAUPI Agassiz, 1843
Figures 29a-f

Material – Judith River Formation, Woodhawk Bonebed: individual teeth, SMM P2003:8:1:1, SMM P2003:8:1:2, and SMM P2003:8:1:3. 3 lateral teeth. Power Plant Ferry Bonebed: individual tooth, SMM P2006:13:1. 1 lateral tooth.

Description – Teeth of *Squalicorax kaupi* have been described by Bilelo (1969), Herman (1977), and Case (1987). Diagnostic features of *S. kaupi* according to Bilelo are: large teeth that range from 3.5 mm to 15 mm in width, 4.5 mm to 15 mm in height; they are thick-rooted with an upper anterior edge inflected sinuously toward the sharp apex. The lower anterior edge is straight or inclines inward to form a moderately angular hump at mid height (a crescentic shape). The cutting edges display strong serrations. The lingual surface is convex with the labial surface flat to concave. *S. kaupi* differs from *S. falcatus* by the angular hump located in the middle of its anterior edge (Evetts, 1979). The specimens found are approximately 10.0 mm wide and typify *S. kaupi* in every other way. The teeth are in pristine or near pristine condition. These may be lateral teeth from either the left side of the lower jaw or the right side of the upper jaw. The root structure is anaulacorhizous with osteodont histology.

Discussion – Because of their similar size and shape *S. kaupi* has been mistaken for other species of *Squalicorax*, namely *S. falcatus*. Bilelo (1969) sought to differentiate between common species of *Squalicorax* using those diagnostic features utilized here. It has been postulated that *S. kaupi* descended from *S. falcatus*, hence the very similar dentition between the two. *S. kaupi* is found from Coniacian to Campanian of North America; Late Cretaceous of Europe, Japan, and New Zealand (Cappetta, 1987), the Maastrichtian of Madagascar (Gottfried et al., 2001), and the Santonian to Maastrichtian of Angola (Antunes and Cappetta, 2002).

SQUALICORAX sp., cf. *S. KAUPI* Agassiz, 1843
Figures 30a-d

Material – Judith River Formation, Woodhawk Bonebed: individual tooth, SMM P2003:8:2. 1 antero-lateral tooth. Power Plant Ferry Bonebed: individual tooth, SMM P2006:13:2. 1 antero-lateral tooth.

Description – These specimens may be *Squalicorax kaupi*, unfortunately there are not enough features to give a more definitive designation beyond the genus level. These specimens are approximately 2.0 mm wide and are presumed to be either underdeveloped teeth or possibly very posterior teeth in the jawline.

Discussion – Because diagnostic features are lacking on these specimens identification is uncertain. However, they strongly resemble the aforementioned specimens and are tentatively referred to as *S. kaupi*.

SQUALICORAX PRISTODONTUS Agassiz, 1843
Figures 31a-d

Material – Judith River Formation, Power Plant Ferry Bonebed: lot and individual teeth, SMM P2006:13:3:1, SMM P2006:13:3:2, and SMM P2006:13:3:3. 4 lateral or anterior teeth.

Description – Teeth of *Squalicorax pristodontus* have a wide size range but can be up to 30.0 mm high. Teeth collected from PPF are rather diminutive <10.0 mm tall. Teeth of this taxon have a triangular crown and strong serrations along the cutting edges (Cappetta 1987). In their 1975 study, Cappetta and Case gave a more quantitative diagnosis for this species, with the symphyseal teeth taller than they are wide and displaying 50 denticles (the serrations) that point to the symphysis. They also lack a distinct heel and have a high, flat root that is convex on the lingual side and flat on the labial side (Cappetta and Case, 1975a). Lateral teeth are wider than tall, have approximately 60 denticles (serrations) on the mesial cutting surface, and have a more pronounced heel of the crown and root (where the root has become asymmetrical) on the distal side of the tooth (Cappetta and Case, 1975a). Case and Cappetta (1997) state that *S. pristodontus* could grow to twice the size of *S. kaupi*, however the *S. pristodontus* samples collected in this study are all approximately the same size as those of *S. kaupi*. The teeth lack a lingual groove but there are many foramina present in the labial face of the root (Cappetta, 1987). The root structure is anaulacorhizous with osteodont histology.

Discussion – This genus is widespread, both in space and time, with *S. pristodontus* (the type species, from the Upper Cretaceous, Maastricht, Holland) found from the Campanian to Maastrichtian, Upper Cretaceous (Cappetta, 1987). Earlier works (Glikman, 1956) have proposed a lineage for *Squalicorax*, with *S. falcatus* giving rise to *S. kaupi* giving rise to *S. pristodontus* (with an overall increase in size, an increasingly blunt apical angle, and a smaller heel [Cappetta, 1987]). However, this hypothesized lineage is based more on stratigraphic distribution then on the morphology, as the changes are gradual (Cappetta 1987). This makes it difficult to erect generic and species boundaries. *S. pristodontus* has previously been documented from the Upper Maastrichtian of Morocco (Arambourg, 1952), the Maastrichtian of Texas (Case and Cappetta, 1997), the Santonian to Maastrichtian of Angola (Antunes and Cappetta, 2002), and from the Campanian to Maastrichtian of New Jersey (Cappetta and Case, 1975a) and now the JRF, Campanian, Upper Cretaceous Montana.

Family ODONTASPIDIDAE Müller and Henle, 1839
Genus *HYPOTODUS* Jaekel, 1895
HYPOTODUS GRANDIS Case, 1978a
Figures 32a-f and 33a-e

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:3:1, SMM P2003:8:3:2 (gold coated), SMM P2003:8:3:3 (gold coated), and SMM P2003:8:3:4-7 (gold coated). 7 teeth. Lot SMM P99:81:1. 10 teeth. Power Plant Ferry Bonebed: lot and individual tooth, SMM P2006:13:4:1 and SMM P2006:13:4:2 (22 teeth).

Description – Large teeth are an important diagnostic feature for this species (Case, 1978a). There is one prominent cusp and 2 to 3 lateral cusplets on either side that are sigmoidal and elongate. Plications are present at the base of the crown where it meets the root. Also present is a nutritive groove on the lingual surface of the root (root structure is holaulacorhizous and osteodont histology). Most teeth collected are just under 5.0 mm in width, and all exhibit 2 or 3 lateral cusplets on either side of the main cusp as well as a nutritive groove.

Discussion – *H. grandis* is very similar to *H. aculeatus* from the Upper Cretaceous of New Jersey (Cappetta and Case 1975a). The similarity between the two species is so strong that it is possible that they may represent the same taxon. The characteristics that Case (1978a) uses to differentiate them are geographic location (New Jersey versus Montana), the difference in size (*H. grandis* teeth are approximately twice the size of those of *H. aculeatus*) and his observation that there is "...an ever so slight different [sic] in the lateral cusp shape" (Case, 1978a: 190). The difference, if it exists, is subtle, and may represent normal variation in a species. At this time, the teeth will be treated as two distinct species of *Hypotodus*, with the teeth from the JRF of Montana representing *H. grandis*. Current age and distribution is the JRF, Campanian, Upper Cretaceous Montana, U.S.A. Occurs also in the Teapot Sandstone Member, "Mesaverde" Formation, Upper Campanian, Wyoming (Case, 1987). No other occurrences are known at this time.

HYPOTODUS sp.
Figures 34a-b

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:4:1, SMM P2003:8:4:2-4, SMM P2003:8:4:5, and SMM P2003:8:4:6. 27 teeth. Power Plant Ferry Bonebed: lot, SMM P2006:13:5. 6 teeth.

Description – Teeth resemble *H. grandis* and *H. aculeatus* although the sizes vary considerably. The teeth are approximately 5.0 mm wide but the spread of the cusplets is not as wide as that seen in *H. grandis* and *H. aculeatus*. The cusp and cusplets are also more elongate than is seen in the aforementioned species. Other than those differences, the rest of the characters are consistent with the characters of *Hypotodus*, one prominent cusp and 2 to 3 lateral cusplets on either side that are sigmoidal and elongate. Plications are present at the base of the crown, and a nutritive groove on the lingual surface of the root (root structure is holaulacorhizous and osteodont histology).

Discussion – Some of these teeth may represent additional variation among *H. grandis* or *H. aculeatus* or they may be a different species. Positive identification has been difficult due to incomplete specimens.

HYPOTODUS sp.
Figures 34c-d

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:5:1, SMM P2003:8:5:2, SMM P2003:8:5:3, and SMM2003:8:5:4. 36 teeth. Power Plant Ferry Bonebed: lot SMM P2006:13:6. 13 teeth.

Description – Teeth differ from the aforementioned lot, the cusp and cusplets are shorter. They resemble *H. grandis* or *H. aculeatus* and conform to all of the overall descriptions of teeth belonging to the Odontaspididae if not to the genus *Hypotodus*. They are under 5.0 mm wide and the spread or span of the cusplets is wide. The cusp and cusplets are shorter, with 2 to 3 lateral cusplets on either side that are sigmoidal. Plications are present at the base of the crown, and some teeth have a nutritive groove on the lingual surface of the root (root structure is holaulacorhizous, histology osteodont).

Discussion – These teeth may represent another species of *Hypotodus* or teeth from the Odontaspididae that belong to another genus.

Family CRETOXYRHINIDAE *sensu lato* Glikman, 1958
Genus *ARCHAEOLAMNA* Siverson, 1992
ARCHAEOLAMNA KOPINGENSIS (Davis, 1890)
Figures 35a-f, 36a-f, 37a-f, and 38a-d

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:7:1, SMM P2003:8:7:2, SMM P2003:8:7:3, SMM P2003:8:7:4, SMM P2003:8:7:5, SMM P2003:8:7:6, SMM P2003:8:7:7, SMM P2003:8:7:8, SMM P2003:8:7:9, SMM P2003:8:7:10, SMM P2003:8:7:11, SMM P2003:8:7:12, SMM P2003:8:7:13, SMM P2003:8:7:14, SMM P2003:8:7:15, SMM P2003:8:7:16, and SMM P2003:8:7:17. 63 teeth. SMM P99:81:2. 14 teeth. Power Plant Ferry Bonebed: lot and individual teeth, SMM P2006:13:7:1, SMM P2006:13:7:2, SMM P2006:13:7:3, and SMM P2006:13:7:4. 45 teeth.

Description – The teeth are large, with a height of approximately 20.0 mm, a width of 10.0 mm (maximum size for the anterior teeth), and an overall triangular shape. One pair of lateral cusplets is present on all teeth, straight and erect on anterior teeth and more flared on lateral and posterior teeth. The roots are thick overall and thickest at the lingual protuberance (root structure is holaulacorhizous, histology osteodont). Plications are present along the base of the crown on the labial surface of the tooth. Minute nutritive foramina can sometimes be observed on the roots.

Discussion – *Archaeolamna kopingensis* was originally named *Lamna arcuata* by Woodward (1894) and was later placed in the genus *Plicatolamna* by Herman (1977). However, when placed in the genus *Plicatolamna*, Herman cited *Odontaspis kopingensis* Davis, 1890 and questioned the validity of Woodward's identification of *Lamna arcuata*. This was not explored again until Siverson (1992). Based on his research, Siverson

(1992) now places this taxon in a new genus he created, *Archaeolamna*, having discovered that the previous name, *Odontaspis kopingensis* Davis, 1890 was attributed to this species, four years prior to Woodward (1894). Under the rules of International Code of Zoological Nomenclature (ICZN) the species name has reverted back to *kopingensis* under the new genus *Archaeolamna* (ICZN, article 79 C [2]). Hereafter, all references to *Plicatolamna arcuata* and/or to *A. kopingensis* in all sources cited and this current work are one and the same. Additionally, while Siverson (1992) has proposed that two subspecies of *A. kopingensis* exist, *A. k. kopingensis* and *A. k. judithensis*, these names are not considered here.

The teeth are found in most Upper Cretaceous (Santonian to Maastrichtian) deposits in the U.S.A. and in Europe (Case, 1978a) and with Cenomanian to Turonian occurrences in Australia (Siverson, 1996 and Kemp, 1991).

Additional notes – Many of the teeth of *A. kopingensis* are in near pristine condition, others are less pristine, and others still broken and/or worn. Some teeth have some discoloration of the enamel in striate patterns (assuming that the crowns of extinct elasmobranchs were originally white to gray in color and with the passage of time take on different colors due to differential diagenesis in different sediments). The striate patterns presumably show the original color of the enamel with the rest of the tooth usually a dark brown in color. These observations posed questions regarding the enamel and overall preservation of the teeth that will be addressed in the taphomony section.

Genus *CRETOLAMNA* Glikman, 1958
CRETOLAMNA APPENDICULATA Agassiz, 1843
Figures 39a-d

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:9:1, SMM P2003:8:9:2, and SMM P2003:8:9:3. 9 teeth. Power Plant Ferry Bonebed: individual teeth, SMM P2006:13:9:1 and SMM P2006:13:9:2. 2 teeth.

Description – Teeth of this species have been described in detail by Cappetta and Case (1975a) and Williamson et al. (1993). Teeth have triangular cusps with broad bases and lateral cusplets (one to three pairs) on either side. They are of medium size and can be as tall as 30.0 mm, have a smooth enameloid crown, and a thick rectangular shaped root lacking nutritive groove and foramina (root structure is holaulacorhizous with secondary loss of the nutritive groove, histology osteodont). The teeth in this study are approximately 15.0 mm tall and 15.0 mm wide, with 1 pair of lateral cusplets, and fit all diagnostic features attributed to this taxon.

Discussion – A new record for the JRF fauna, the species is cosmopolitan and known from the Albian to Ypresian in Europe, Albian through Maastrichtian in North America (Cappetta, 1987), the Cretaceous of Japan (Research Group for Mesozoic Fossil Sharks, 1977) and the Cretaceous of Australia (Kemp, 1991 and Siverson, 1996).

Genus *PROTOLAMNA* Cappetta, 1980a
PROTOLAMNA SOKOLOVI Cappetta, 1980a (= *ARCHAEOLAMNA KOPINGENSIS JUDITHENSIS* of Siverson, 1992)
Figures 40a-f and 41a-d

1980a *Protolamna sokolovi* Cappetta, pages 32-34, figure 2
1987 *Protolamna sokolovi* Cappetta, pages 102-103, figure 90
1992 *Archaeolamna kopingensis kopingensis* Siverson, pages 531-533, plate 2, figures 3-4

1992 *Archaeolamna kopingensis judithensis* Siverson, pages 534, plate 2, figures 16-18
1993 *Protolamna* aff. *sokolovi* Welton and Farish, pages 110-111, figures 1-9

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:8:1, SMM P2003:8:8:2, SMM P2003:8:8:3 (gold coated), and SMM P2003:8:8:4. 8 intermediate (?) teeth. Power Plant Ferry Bonebed: individual teeth, SMM P2006:13:8:1 and SMM P2006:13:8:2. 2 teeth.

Description – The teeth in this study are believed to be intermediate teeth due to their small size (maximum height is 10.0 mm seen on one specimen, all others are 5.0 mm tall or shorter), with tall cusps, and a "kinked" appearance to the cusps. This species was first described by Cappetta (1980a) from the Upper Aptian of southern France. The teeth have a proportionally large root and small broad-based straight crown (anterior teeth). Additionally, the root and the crown are approximately equal in height. Overall tooth size can be up to 20.0 mm tall. Plications and enameloid folds may be present on the flat labial surface of the crown. Single cusplets are present on either side of the main cusp, situated low on the crown, and widely separated from the main cusp in lingual view. The root lacks a nutritive groove (or rarely has a short small one) and foramina (root structure is holaulacorhizous with secondary loss of the nutritive groove and osteodont histology).

Discussion – The taxon is a new record for the JRF, unless it should prove to be a subspecies of *Archaeolamna*; teeth with a similar morphology have been attributed to this genus in recent papers and have created some confusion regarding the proper designation of teeth as assigned by Case in 1978a and 1987.

There is some confusion regarding the taxonomic status of *Archaeolamna kopingensis kopingensis* and other subspecies since Siverson's work in 1992. Siverson (1992) reviewed Case's work (1978a and 1987) and decided that when Case identified *Plicatolamna arcuata* it was in fact a subspecies of *Archaeolamna*. He has since renamed the species as *Archaeolamna kopingensis judithensis* Siverson 1992. The validity of this subspecies designation is dubious given the undetailed description provided by Siverson. The description, along with the images provided in Siverson (1992) show that there is very little difference between the two subspecies that he has constructed (any differences could be attributed to normal variation within the species). For the purposes of this study the two subspecies are considered the same taxon and treated here as *Archaeolamna kopingensis* (Davis, 1890). *Archaeolamna kopingensis kopingensis* and/or *Archaeolamna kopingensis judithensis* are therefore referred to *Archaeolamna kopingensis* (therefore Case's identifications [1978a and 1987] are correct).

Following from the above, the issue of *Protolamna sokolovi* can then be addressed. Overall descriptions of the genera *Archaeolamna* as noted by Siverson (1992) and *Protolamna* (utilizing *Protolamna* descriptions by Cappetta [1980a] which are also in Cappetta [1987] and Welton and Farish [1993]) seem to adequately separate the two taxa from each other. However, in Siverson (1992) some of the teeth labelled as *A. k. kopingensis* and *A. k. judithensis* (as para/symphyseal teeth) more closely correspond to the descriptions of *P. sokolovi* than to either of Siverson's descriptions of the subspecies of *A. k. kopingensis* or *A. k. judithensis*. If these teeth belong to *P. sokolovi*, it is a new taxon for the JRF and a geographic range extension for the taxon. If, however subsequent researchers decide the teeth belong to *A. kopingensis*, then they are the first para/symphyseal teeth of *A. kopingensis* from the JRF in Montana.

Distribution and age for *P. sokolovi* are Upper Aptian to Albian, lower Cretaceous, Europe, former Soviet Union, North America (Cappetta, 1987), with occurrences in the Albian of Texas (Welton and Farish, 1993), and now extended to the Campanian of Montana if the identification suggested herein is correct. The *Protolamna* genus does occur in Campanian and Maastrichtian of Texas (Welton and Farish, 1993) so it would not improbable to find *P. sokolovi* in the Campanian of Montana.

Order CARCHARHINIFORMES Compagno, 1973
Family TRIAKIDAE Gray, 1851
Genus *ARCHAEOTRIAKIS* Case, 1978a
ARCHAEOTRIAKIS ROCHELLEAE Case, 1978a
Figures 42a-d

Material – Judith River Formation, Power Plant Ferry Bonebed: individual teeth, SMM P2006:13:23:1 and SMM P2006:13:23:2. 2 teeth.

Description – Case's diagnosis for this genus and species are teeth of minute size with tooth height less than 0.5 millimeters and an overall robust structure (Case, 1978a). The tricuspid crown is broad and thick and consists of a straight central bulky cusp with a flanking pair of widely diverging lateral cusplets (Cappetta, 1987). The rather smooth surface of the lingual face lacks a lingual protuberance while the labial face displays ridges or "pleats" (Case, 1978a) that are directed vertically along the central cusp and lateral cusplets with lesser ridges or folds in between (Cappetta, 1987). The root structure is holoaulacorhizous.

Discussion – The systematic placement of *Archaeotriakis rochelleae* has been problematic since it was first erected. Initially Case (1978a) placed the species in the Family Pseudotriakidae (Brito Capello, 1867*), but Cappetta (1987) placed them in the Family Triakidae and Tribe Triakini Gray, 1851. However, Cappetta acknowledged that placement within Triakini at that time was hypothetical (Cappetta, 1987). The current range and distribution of *A. rochelleae*, the type species, is Upper Cretaceous of North America, with the first occurrence from the Judith River Formation, Montana (Cappetta, 1987).

Order RAJIFORMES Berg, 1940
Family HYPSOBATIDAE Cappetta, 1992
Genus *PROTOPLATYRHINA* Case, 1978a
PROTOPLATYRHINA RENAE Case, 1978a
Figures 43a-m and 44a-i

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:11:1, SMM P2003:8:11:2, SMM P2003:8:11:3 (gold coated), SMM P2003:8:11:4 (gold coated), SMM P2003:8:11:5, SMM P2003:8:11:6, SMM P2003:8:11:7, SMM P2003:8:11:8 (gold coated), SMM P2003:8:11:9, SMM P2003:8:11:10, SMM P2003:8:11:11 (gold coated), SMM P2003:8:11:12, SMM P2003:8:11:13, and SMM P2003:8:11:14. 574 teeth. SMM P99:81:4:1. 46 teeth. Power Plat Ferry Bonebed: lot and individual teeth, SMM P2006:13:11:1, SMM P2006:13:11:2, SMM P2006:13:11:3, SMM P2006:13:11:4, and SMM P2006:13:11:5. 445 teeth.

Woodhawk Bonebed: lot and individual dermal denticles, SMM P2003:8:11:15, SMM P2003:8:11:16, and SMM P2003:8:11:17. 280 dermal denticles. SMM P99:81:4:2. 28 dermal denticles. Power Plant Ferry Bonebed: lot and individual dermal denticles, SMM P2006:13:11:6, SMM P2006:13:11:7, and SMM P2006:13:11:8. 220 dermal denticles.

Description – Case's (1978a) diagnosis for this genus and species is teeth of small size ranging from 0.25 mm to 2.0 mm in diameter and 0.75 mm in height. Overall crown

*The work Case refers to is actually de Brito Capello, 1867 or 1868, however Pseudotriakidae is first described by Gill (1893) emended from Scylliorhinidae by Jordan and Evermann (1896), and not by de Brito Capello as Case (1978a) stated.

shape is thick, smooth, and rhombodic to hexagonal (with the sides of the teeth being interlocking faces or facets) or circular to oval (or oblong) in occlusal view. Large foramina are present on lateral facets located directly below the crown's enameloid apron. A medial furrow is present in basal view (the root structure is holaulacorhizous, and histology orthodont). Teeth collected for this study range from 0.25 mm to 2.0 mm in diameter are circular (in addition to oval and rhombic) in occlusal view and exhibit all characters in Case's diagnosis except for the foramina (which may be obscured by matrix). There are also several teeth that do not have the root preserved. Case also described dermal denticles of *P. renae*, found in association with *P. renae* teeth, which are small and look rather buttonlike. Dermal denticles appear as inverted mushrooms and are just over 1.0 mm in diameter.

Discussion – After much ambiguity on taxonomic placement, from Rhinobatidae (Müller and Henle, 1838) to Platyrhinidae (Jordan, 1923), Cappetta (1992) assigned *Protoplatyrhina* to the family Hypsobatidae (Cappetta, 1992). Age and distribution is the JRF, Campanian, Upper Cretaceous Montana, U.S.A. (Cappetta, 1987), Maastrichtian of Texas (Welton and Farish, 1993), Kemp Formation, Upper Maastrichtian north-eastern Texas (Case and Cappetta, 1997), as well as the Teapot Sandstone Member, "Mesaverde" Formation, Upper Campanian, Wyoming (Case, 1987), and the Dinosaur Park Formation, Upper Campanian Alberta, Canada (Beavan and Russell, 1999).

Family RHINOBATIDAE Müller and Henle, 1838
Genus *SQUATIRHINA* Casier, 1947b
SQUATIRHINA sp.
Figures 45a-b

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:13:1 (gold coated) and SMM P2003:8:13:2. 13 teeth.

Description – First described by Casier (1947b), teeth of this genus are small, up to 5.0 mm tall and 1.5 mm wide. They have a distinct cuspidate crown, bulbous lingual protuberance, and scalloped crown margin. The root has a triangular outline, a nutritive groove (root structure is holaulacorhizous, histology orthodont) and foramina on the root (very similar in overall appearance to *Cretorectolobus olsoni* and/or *Eucrossorhinus microcuspidatus* but the cusp is more recurved in *Squatirhina* than in *C. olsoni* or *E. microcuspidatus*). Teeth collected here fall within the size range, approximately 3.0 mm tall and 1.0 mm wide, and foramina are either lacking or obscured by matrix.

Discussion – The known age and distribution of the genus ranges from the Turonian to Maastrichtian of Europe (Cappetta, 1987). Estes (1964) named a species of *Squatirhina* from the Lance Formation of Wyoming and later recorded an occurrence of *Squatirhina* from the Hell Creek Formation, Montana (Estes et al., 1969). *Squatirhina* has also been found in the Weno Formation (Albian) in Tarrant County and the Pepper Formation (Cenomanian) in Bell County, Texas (Welton and Farish, 1993), and in the Teapot Sandstone Member, "Mesaverde" Formation (Upper Campanian), Wyoming (Case, 1987). The material noted here is the first notice of *Squatirhina* for the JRF, Montana.

Suborder SCLERORHYNCHOIDEI Cappetta, 1980b
Family SCLERORHYNCHIDAE Cappetta, 1974
Genus *ISCHYRHIZA* Leidy, 1856b
ISCHYRHIZA AVONICOLA Estes, 1964

Material – Judith River Formation, Woodhawk Bonebed: individual tooth, SMM P2003:8:12. 1 broken rostral tooth.

Description – Rostral teeth are small and short with the crown less than half the tooth height and with a convex anterior cutting ridge extending from apex to the crown foot. The root is widely splayed and expands continuously from the crown foot to the base. Oral teeth of this species are very small (less than 2.0 mm wide) and appear very much like other sclerorhynchid oral teeth. The crown is a rounded apical edge without a distinct cusp. They have a nutritive groove (root structure is holaulacorhizous, histology orthodont). Only one rostral tooth was collected. The tooth is approximately 10.0 mm in length. Because most oral teeth of batoids are difficult to identify without associated rostral teeth and/or clear diagnostic features, any oral teeth from Family Sclerorhynchidae in this study are identified as *Ptychotrygon hooveri*, *P. triangularis*, or Sclerorhynchidae indet.

Discussion – Found in western North American Late Cretaceous faunas, the age and distribution of the species is Late Cretaceous (Turonian to Maastrichtian) of the United States (Cappetta, 1987).

ISCHYRHIZA MIRA Leidy, 1856b
Figures 46a-c

Material – Judith River Formation, Woodhawk Bonebed: lot and individual rostral teeth SMM P2003:8:14:1, SMM P2003:8:14:2, SMM P2003:8:14:3, and SMM P2003:8:14:4. 63 rostral teeth. SMM P99:81:5. 66 rostral teeth/pieces. Power Plant Ferry Bonebed: lot SMM P2006:13:12. 34 rostral teeth/pieces.

Description - Rostral teeth are laterally compressed, slightly sigmoidal, and as long as 60.0 mm. The crown is thick with smooth enameloid, and tends to be shorter than the root, with sharp anterior and posterior cutting edges. Oral teeth of this species are small, up to 7.0 mm wide and with the appearance of typical sclerorhynchid oral teeth. They have cuspidate crowns, a nutritive groove (root structure is holaulacorhizous and orthodont histology), and foramina. Only rostral teeth were recovered, with lengths of approximately 15.0 mm, and all lack the roots.

Discussion – Found in many North American Late Cretaceous faunas (Case, 1978a), the age and distribution of the species is Late Cretaceous (Turonian to Maastrichtian) of the United States (Cappetta, 1987); the Foremost Formation, Campanian of Alberta, Canada (Storer and Johnson, 1974); the Black Creek Formation, Campanian, North Carolina (Robb, 1989); and the Maastrichtian of Maryland (Hartstein and Decina, 1986).

Genus *PTYCHOTRYGON* Jaekel, 1894
PTYCHOTRYGON HOOVERI McNulty and Slaughter, 1972
Figures 47a-d

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:15:1, SMM P2003:8:15:2 (gold coated), and SMM P2003:8:15:3. 10 oral teeth. SMM P99:81:6. 1 oral tooth. Power Plant Ferry Bonebed: lot SMM P2006:13:13. 5 oral teeth.

Description – McNulty and Slaughter (1972) describe these teeth as small, between 1.0 and 2.0 mm wide and tall, and with high, narrow, triangular cuspidate smooth crowns with little or no ornamentation. Root is triangular in outline and with a nutritive groove (root structure is holaulacorhizous, histology orthodont). Teeth collected in this study exhibit all features as described.

Discussion – Age and distribution includes the Eagle Ford Formation, Late Turonian, Late Cretaceous, Dallas area, Texas, U.S.A. (Cappetta, 1987), as well as the Pepper and Woodbine Formations (Cenomanian), and the Atco Formation of the Austin Group (Coniacian) (Welton and Farish, 1993).

PTYCHOTRYGON TRIANGULARIS Reuss, 1844
Figures 48a-b

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:16:1 and SMM P2003:8:16:2. 3 oral teeth. SMM P99:81:7. 1 oral tooth. Power Plant Ferry Bonebed: lot, SMM P2006:13:14. 6 oral teeth.

Description – Teeth are small, between 1.0 and 3.0 mm wide and 1.0 and 2.0 mm tall, with high triangular crowns with three prominent separate transverse ridges along the lingual face. Root is triangular in outline and has a nutritive groove (root structure is holaulacorhizous, orthodont histology). Teeth collected exhibit all features as described.

Discussion – Age and distribution includes the Woodbine and Pepper formations (Cenomanian), Eagle Ford Group (Cenomanian to Turonian), Austin Group (Coniacian to Santonian), and the Taylor and Navarro groups (Campanian and Maastrichtian) in Texas (Welton and Farish, 1993); Upper Cretaceous (Coniacian) of the Dalton Sandstone of Central New Mexico (Johnson and Lucas, 2001); and Turonian, Late Cretaceous, in what used to be Bohemia, Czechoslovakia (Cappetta, 1987) now modern day Czech Republic.

Also occurs in the Turonian of South Dakota (Cappetta, 1973) and the Cenomanian-Turonian of Arizona (Williamson, et al., 1993).

SCLERORHYNCHIDAE indet.
Figures 49a-f and 50a-c

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:17:1, SMM P2003:8:17:2 (gold coated), SMM P2003:8:17:3 (gold coated), SMM P2003:8:17:4 (gold coated), SMM P2003:8:17:5 (partial gold coating), and SMM P2003:8:17:6. 25 oral teeth. SMM P99:81:8. 5 oral teeth. Power Plant Ferry Bonebed: lot SMM P2006:13:15. 6 oral teeth.

Description – Teeth are small, up to 5.0 mm wide. Overall appearance superficially resembles *Ptychotrygon* or *Ischyrhiza*. There is no ornamentation, the crown is triangular and cuspidate, and the root has a nutritive groove (root structure is holaulacorhizous, histology orthodont). Teeth are much larger and more robust than *P. hooveri* or *P. triangularis*.

Discussion – These could be teeth of *Ischyrhiza*, in particular *I. mira* or *I. schneideri* (SMM P2003:8:17:3), but some teeth also resemble *Onchoprisitis dunklei* (SMM P2003:8:17:2). They are all of appropriate size and overall shape to be classified as a sclerorhynchid.

Order MYLIOBATIFORMES Compagno, 1973
Family DASYATIDAE Berg, 1958
Genus *MYLEDAPHUS* Cope, 1876a
MYLEDAPHUS BIPARTITUS Cope, 1876a
Figures 51a-h

Material – Judith River Formation, Woodhawk Bonebed: lot and individual teeth, SMM P2003:8:18:1, SMM P2003:8:18:2 (gold coated), and SMM P2003:8:18:3. 12

teeth/pieces. SMM P99:81:9:1. 5 teeth. Power Plant Ferry Bonebed: individual tooth SMM P2006:13:16:1. 1 tooth.

Woodhawk Bonebed: lot an individual dermal denticle, SMM P2003:8:18:4 and SMM P2003:8:18:5. 12 dermal denticles. SMM P99:81:9:2. 1 dermal denticle. Power Plant Ferry Bonebed: lot, SMM P2006:13:16:2. 2 dermal denticles.

Description – First described and named by Cope (1876a), discovered in 1876 by Sternberg in the JRF. Cope's original description shows teeth of hexagonal outline and crowns molariform in structure (truncate), wider than long and positioned on the roots in a table-like fashion. Estes (1964) made further observations while studying the Lance Formation fauna in Wyoming. Teeth up to 7.0 mm wide, tending to display wrinkles on the sides of the crown. Overall outline is rhombic to hexagonal with the smaller teeth more irregular in shape, more elongate and narrow, and lacking wrinkles (Cope, 1876a). Most of the teeth collected here are approximately 1.0 to 2.0 mm tall and wide and display the rhombic outline. They are not as large or robust as typical *Myledaphus bipartitus* teeth, however they do fit the overall morphological criteria for the species (as determined by Estes, 1964), particularly for the smaller teeth. There is, however, one tooth, from PPF (SMM P2006:13:16:1) that is larger and closer to the size range as originally described by Cope (1876a). Dermal denticles, as described and illustrated in Estes (1964) were also found, approximately 5.0 mm in diameter. The denticles are round, oval in shape in dorsal view, and conical in profile view with ridges that run from the apex of the denticle to the basal edge.

Discussion – As already mentioned, most of the teeth collected do not fit the normal size criteria of *M. bipartitus* but it should be noted that Sahni (1972) and Case (1978a) found teeth they identified as *M. bipartitus* that were between 2.0 and 5.0 mm in size. If these teeth are not small *M. bipartitus* teeth then they are possibly another species of *Myledaphus*, as they exhibit the strong rhombic outline. These teeth could also pertain to the Rhombodontidae, which are similarly rhombic. *M. bipartitus* is quite abundant in Late Cretaceous North America (Wyoming, Montana, New Mexico, and Saskatchewan). Age and distribution includes Cretaceous of North America and the former Soviet Union (Cappetta, 1987).

Subclass SUBTERBRANCHIALIA Zangerl, 1979
Superorder HOLOCEPHALI Bonaparte, 1832
Order CHIMAERIFORMES Obruchev, 1953
Suborder CHIMAEROIDEI Patterson, 1965
Family CALLORHYNCHIDAE Garman, 1901
Genus *ISCHYODUS* Egerton, 1843
Figure 52

Material – Judith River Formation, Woodhawk Bonebed: lot and individual pieces, SMM P2003:8:23:1 and SMM P2003:8:23:2. 35 partial tooth plates.

Description – Pieces of tooth plates are too fragmentary and friable for positive identification beyond the genus level and jaw position. However, they may represent one of two species found by Case (1979) from the JRF in 1978, *Ischyodus bifurcatus* Case 1978b or *Elasmodus* cf. *E. greenoughi* Agassiz, 1843. Fragments recovered more closely resemble tooth plates of the genus *Ischyodus* than those belonging to *Elasmodus*, with pieces containing the same pitted or punctate occlusal surface texture of the tooth plates as *Ischyodus*. Unfortunately no real systematic comparisons can be done due to the fragmentary nature of the specimens. If, however, the pieces belong to *Elasmodus*, the systematic placement changes to the Family Rhinochimaeridae.

Discussion – Modern day chimaerids are typically deep-sea forms, and it is usually inferred that extinct chimaerids also inhabited deep-water environments. However, most fossil chimaerids are found in shallow marine deposits (much like the JRF), perhaps through postmortem transport. Tooth plate structure indicates that chimaerids were durophagus. *Ischyodus bifurcatus* is found in Upper Cretaceous (Upper Santonian to Middle Maastrichtian) deposits of New Jersey and Delaware, the Campanian deposits of Arkansas, California, and Montana; Campanian of Belgium, mid-Campanian of Georgia, and the Campanian of the Volgograd region of Russia (Stahl, 1999). *Elasmodus greenoughi* is known from the Upper Cretaceous of Belgium and the JRF of Montana (Stahl, 1999).

CHONDRICHTHYES indet.

Material – Judith River Formation, Woodhawk Bonebed: lot SMM P2003:8:21:1 and SMM P2003:8:21:2. 61 dermal denticles. SMM P99:81:10. 12 dermal denticles. Power Plant Ferry Bonebed: lot SMM P2006:13:19. 61 dermal denticles.

Description – Dermal denticles are mostly very pointed and conical like those of *Myledaphus bipartitus*, however, many have a "kink" in the cone that *M. bipartitus* does not seem to possess. The dermal denticles are also much smaller than *M. bipartitus*, roughly the size of *Protoplatyrhina renae*. The denticles might come from sharks and/or skates and rays and possibly even from chimaerids, but because there has been little interest in dermal denticles (Cappetta [1987] attributed this lack of interest to the small size of the denticles) there is very little comparative information available. A recent study by Herman et al. (1995) concentrated mostly on teeth but also included some information regarding dermal denticles in a series of papers on the Batomorphii. A faunal study by Deslate et al. (2002) examined dermal denticles that are believed to belong to sharks and chimaeroids. However, dermal denticles identified in these studies did not correspond with any of the material collected in the current study.

Discussion – Dermal denticles collected from the Greenhorn Cyclothem in Arizona (Williamson et al., 1993) were separated into five categories (types A-E) based on different morphologies. Some of the unidentified denticles in this JRF collection superficially resemble some of the Greenhorn dermal denticles (types A and B) – namely the "kinked" cone dermal denticles. Williamson et al. (1993) were not able to identify the dermal denticles any further due to lack of associated teeth. By drawing on Case (1978a) and Cappetta (1987), Williamson et al. conjectured that the majority of the dermal denticles were batoid in origin, possibly from batoids found in their study (*Ischyrhiza avonicola*, *I. mira*, *I. schneideri*, *Onchopristis dunklei*, *Ptychotrygon triangularis*, *Protoplatyrhina hopii*, and *Pseudohypolophus mcnultyi*) (Williamson et al., 1993). A similar conclusion may be drawn for the JRF as the dermal denticles are not associated with any particular teeth and seem more batoid in appearance when compared to the current literature.

Additional studies by Gravendeel et al. (2002), Deslate et al. (2002), Deynat and Séret (1996), and Deynat (1998 and 2000a-b) have developed new terminology to describe the wide range of varieties and morphologies seen in dermal denticles. The aim in these studies has been to try to develop a nomenclature for the dermal denticles as for teeth for taxonomic and identifying purposes. Gravendeel et al. (2002) has gone so far as to develop a dichotomous key for recent skates and rays of the North Sea region. However, a similar problem exists for dermal denticles as with shark teeth, heterodonty. Despite the advances being made in the study of dermal denticles, denticles identified in these works did not correspond with any of the material collected here.

Division TELEOSTEI *sensu* Arratia, 1999
Supercohort ELOPOMORPHA Greenwood et al., 1966
Order ELOPIFORMES Greenwood et al., 1966
Family PHYLLODONTIDEA Dartevelle and Casier, 1943
Genus *PARALBULA* Blake, 1940
PARALBULA CASEI Estes, 1969a
Figures 53a-b

Material – Judith River Formation, Woodhawk Bonebed: lot SMM P2003:8:24. 1 partial pharyngeal tooth plate.

Description – First described by Estes (1969a); teeth are set in a pharyngeal tooth plate that is flattened and bears 2 to 3 layers of teeth. The individual teeth are hemispherical and approximately 1.0 mm in diameter. The partial tooth plate here exhibits all features listed.

Discussion – The type specimen was discovered by Case and later named for him by Estes (1969a), from the type locality Reservoir Creek (a tributary of Ramenesson Brook), Harding Farm, Holmdel, Monmouth County, New Jersey. The known range of *Paralbula casei* is Late Cretaceous of Montana (in the JRF by Case, 1978a), Alberta, New Jersey, and North Carolina (Robb, 1989), and in the early Eocene of England (Estes, 1969a).

Infraclass ARCHOSAURIA Cope, 1869
Superorder CROCODYLOMORPHA Walker, 1970
Order CROCODYLIFORMES Hay, 1930

Material - Judith River Formation, Woodhawk Bonebed: lot SMM P2003:8:27. 2 teeth. SMM P99:81:31. 1 tooth. Power Plant Ferry Bonebed: lot SMM P2006:13:21. 1 tooth.

Description – The crocodile teeth collected are approximately 10.0 mm in height. They are conical in shape with faint traces of carinae, a character of many archosaur teeth.

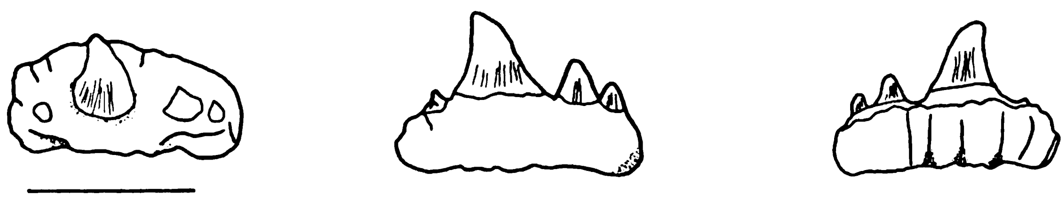
Discussion – The crocodile teeth collected were the only identifiable non-fish specimens recovered in this collection. Crocodilian material was among the first fossils described from the JRF (Leidy, 1856a).

ADDITIONAL MATERIAL

Additional material from the two bonebeds (WH and PPF) consists of pieces of prismatic cartilage. Five pieces were retrieved from WH (SMM P2003:8:20) and PPF yielded 25 pieces (SMM P2006:13:18). Prismatic cartilage has a stippled texture rather like that of a basketball. Preserved cartilage indicates paleoenvironmental conditions were favorable enough for fine preservation of very delicate material. Shark tooth fragments (consisting of cusps, cusplets, roots, etc.) from both WH (SMM P2003:8:22, lot of 188 fragments and SMM P99:81:11, lot of 35 fragments) and PPF (SMM P2006:13:20, lot of 119 fragments), most likely consisting of *Hypotodus* sp., *Archaeolamna* sp., *Ischyrhiza* sp., and teleost fishes were also gathered from the bulk samples and screened material. Some material may be referable to *Enchodus* from both WH (SMM P2003:8:26, lot 3 partial teeth and SMM P99:81:14, lot of 5 partial teeth) and PPF (SMM P2006:13:22:1, lot of 3 partial teeth). Additional material also includes chondrichthyan and teleost centra from both WH (SMM P2003:8:19:1-4, lot of 644 centra) and PPF (SMM P2006:13:17, lot of 349 centra) with centra ranging from less than 1.0 mm in diameter to 10.0 millimeters in diameter. Some contain fenestrations, and foramina, all are circular in shape and amphicoelous. The centra were not identified as most were very fragile and covered with matrix.

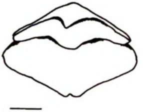
There are additional teleost teeth that are currently unidentifiable and may not be identifiable due to lack of diagnostic features. Teeth were recovered from WH (SMM P2003:8:25:1, lot of 19 teeth) that are elongate and taper to a sharp point with sizes of up to 2.0 or 3.0 mm in length. The teeth lack diagnostic features. The other morphotype of teleost teeth are rounded caps less than 1.0 mm in diameter to approximately 2.0 mm in diameter. There are no other features on the teeth that can be used in identifying them (also from WH, SMM P2003:8:25:2, lot of 35 teeth and SMM P99:81:16, lot of 1 tooth).

Finally, miscellaneous fragments were recovered from both bonebeds. Undifferentiated material (a mix of teeth, centra, and bone from shark, skate, ray, teleost, and perhaps reptile and turtle) from the WH site (SMM P99:81:12) and from the PPF site (SMM P2006:13:27), and smaller unsorted fragments of similar composition (SMM P2006:13:34), were separated from the identifiable material. Potential shark spines (SMM P2006:13:25, lot of 6 spine? shark pieces), possible turtle material, (SMM P2006:13:26, lot of 48 turtle (?) pieces), and unidentified bones (SMM P2006:13:28, lot of 5 big bone pieces) were also recovered from PPF.

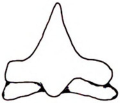


27a. 27b. 27c.

Figure 27. Drawings of *Hybodus montanensis* tooth (a. occlusal view, b. labial view, c. lingual view), SMM P2003:8:6:1. Scale bar = 1.0 mm a-c.

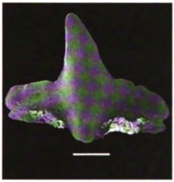


28a.

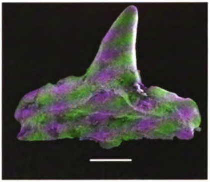


28b.

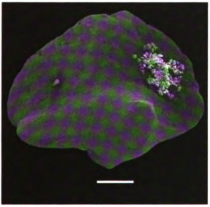
28c.



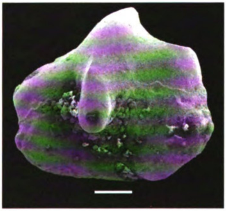
28d.



28e.



28f.



28g.

Figure 28. Anterior tooth drawings of *Cretorectolobus olsoni* (a. occlusal view, b. labial view, c. lingual view), SMM P2003:8:10:1. SEMs of antero-lateral teeth of *Cretorectolobus olsoni* (d. labial view, e. lingual view), SMM P2003:8:10:2 and (f. occlusal view, g. labial-basal view), SMM P2003:8:10:3. Scale bar = 1.0 mm for a-g.

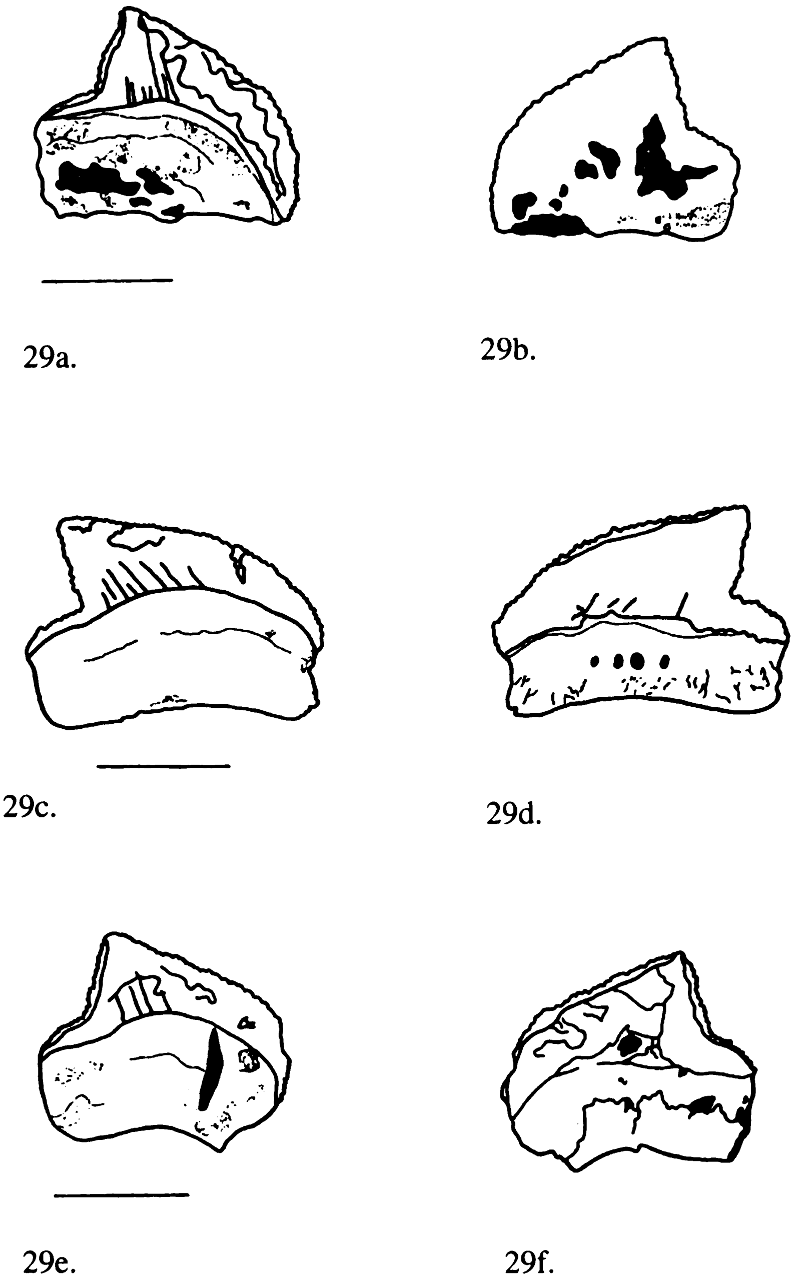
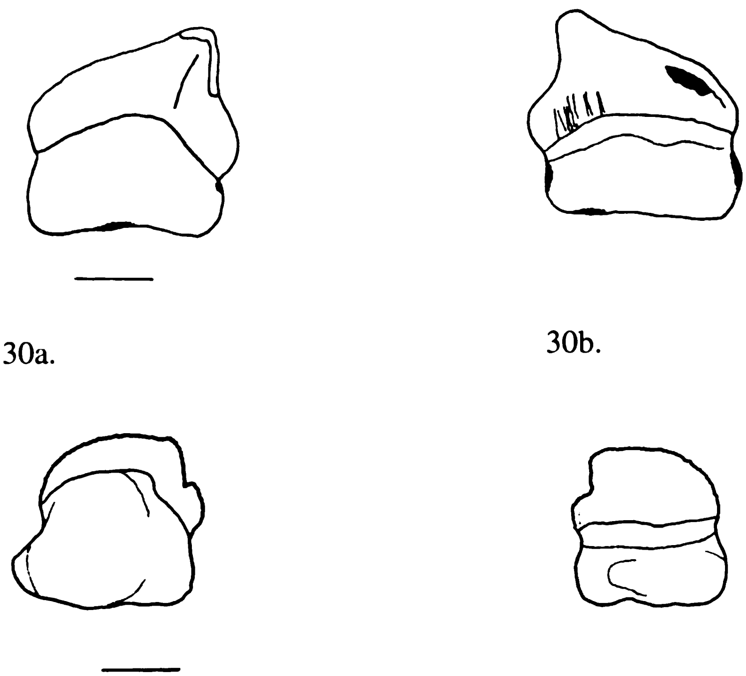
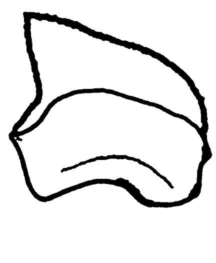


Figure 29. Drawings of *Squalicorax kaupi* lateral teeth (a. lingual view, b. labial view), SMM P2003:8:1:1, (c. lingual view, d. labial view) SMM P2003:8:1:2, and (e. lingual view, f. labial view), SMM P2003:8:1:3. Scale bar = 5.0 mm a-f.

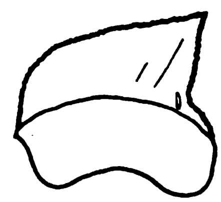


30a. 30b. 30c. 30d.

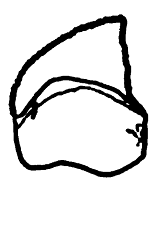
Figure 30. Drawings of *Squalicorax* sp., cf. *S. kaupi* teeth (a. lingual view, b. labial view), SMM P2003:8:2 and (c. lingual view, d. labial view), SMM P2006:13:2. Scale bar = 1.0 mm a-d.



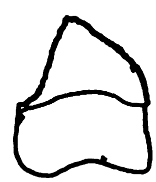
31a.



31b.



31c.



31d.

Figure 31. Drawings of *Squalicorax pristodontus* teeth (a. lingual view, b. labial view), SMM P2006:13:3:1 and (c. lingual view, d. labial view), SMM P2006:13:3:2. Scale bar = 5.0 mm a-d.

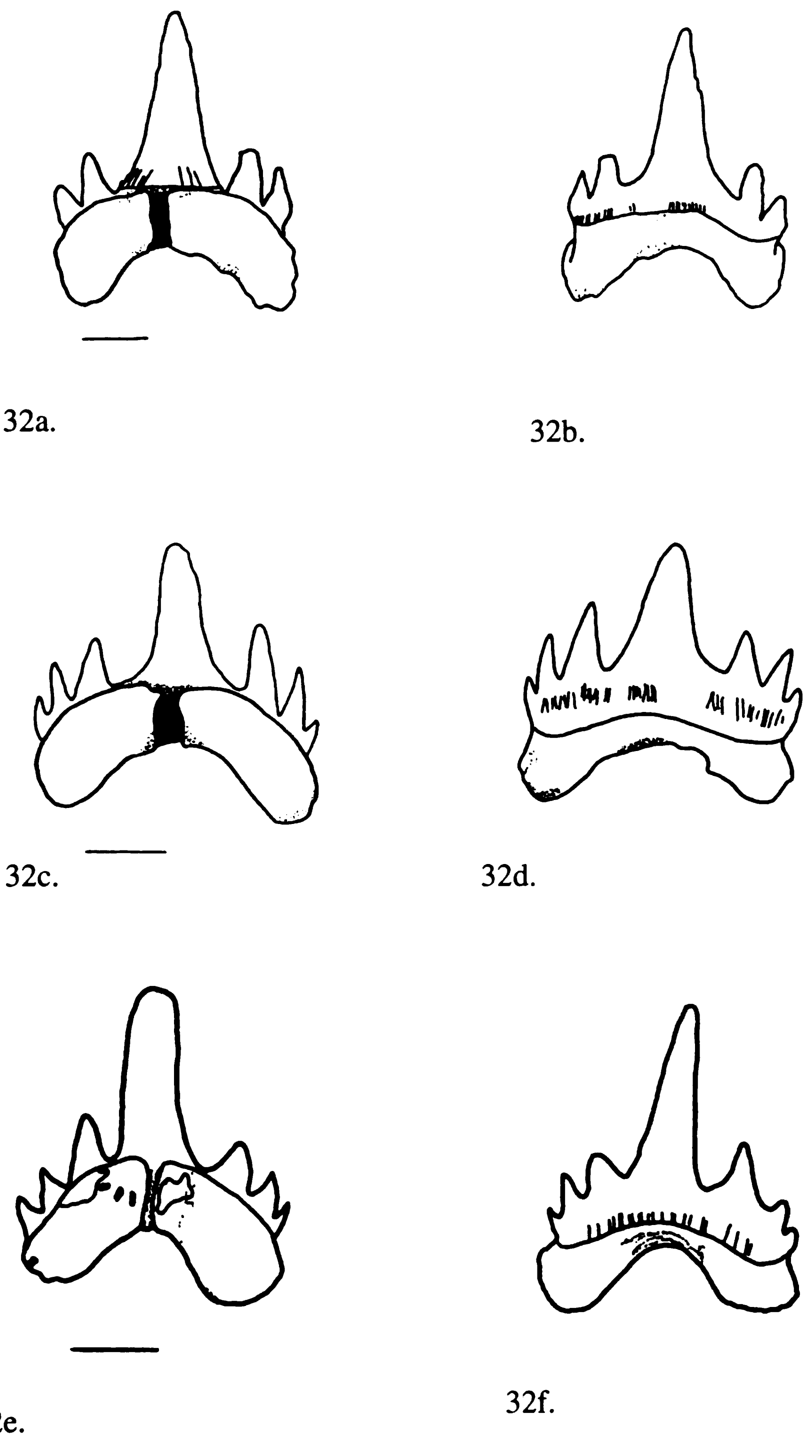
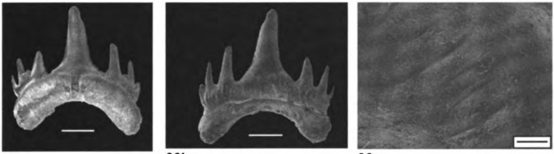
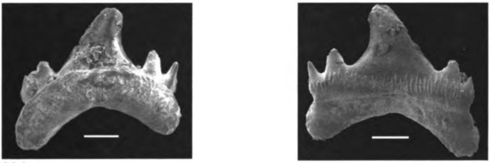


Figure 32. Drawings of *Hypotodus grandis* teeth (a. lingual view, b. labial view), SMM P2003:8:3:1, (c. lingual view, d. labial view), SMM P2003:8:3:2, and (e. lingual view, f. labial view), SMM P2006:13:4:1. Scale bar = 1.0 mm a-f.

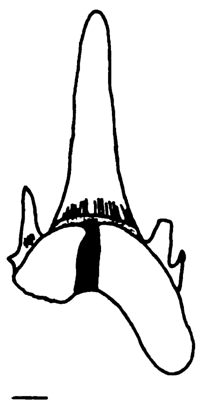


33a. 33b. 33c.

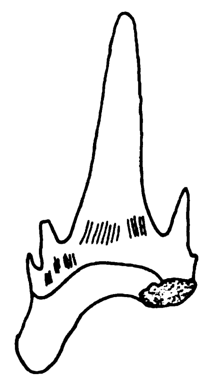


33d. 33e.

Figure 33. SEMs of *Hypotodus grandis* teeth (a. lingual view, b. labial view, c. close-up of plications on labial face), SMM P2003:8:3:2 and (d. lingual view, e. labial view), SMM P2003:8:3:3. Scale bar = 1.0 mm for a-b, d-e and 0.1 mm for c.

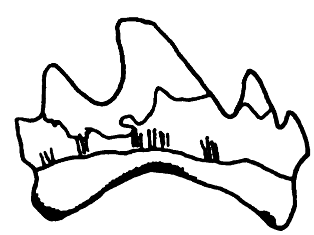


34a.



34b.

34c.



34d.

Figure 34. Drawings of *Hypotodus* sp. teeth (a. lingual view, b. labial view), SMM P2003:8:4:1 and *Hypotodus* sp. teeth (c. lingual view, d. labial view), SMM P2003:8:5:1. Scale bar = 1.0 mm for a-d.

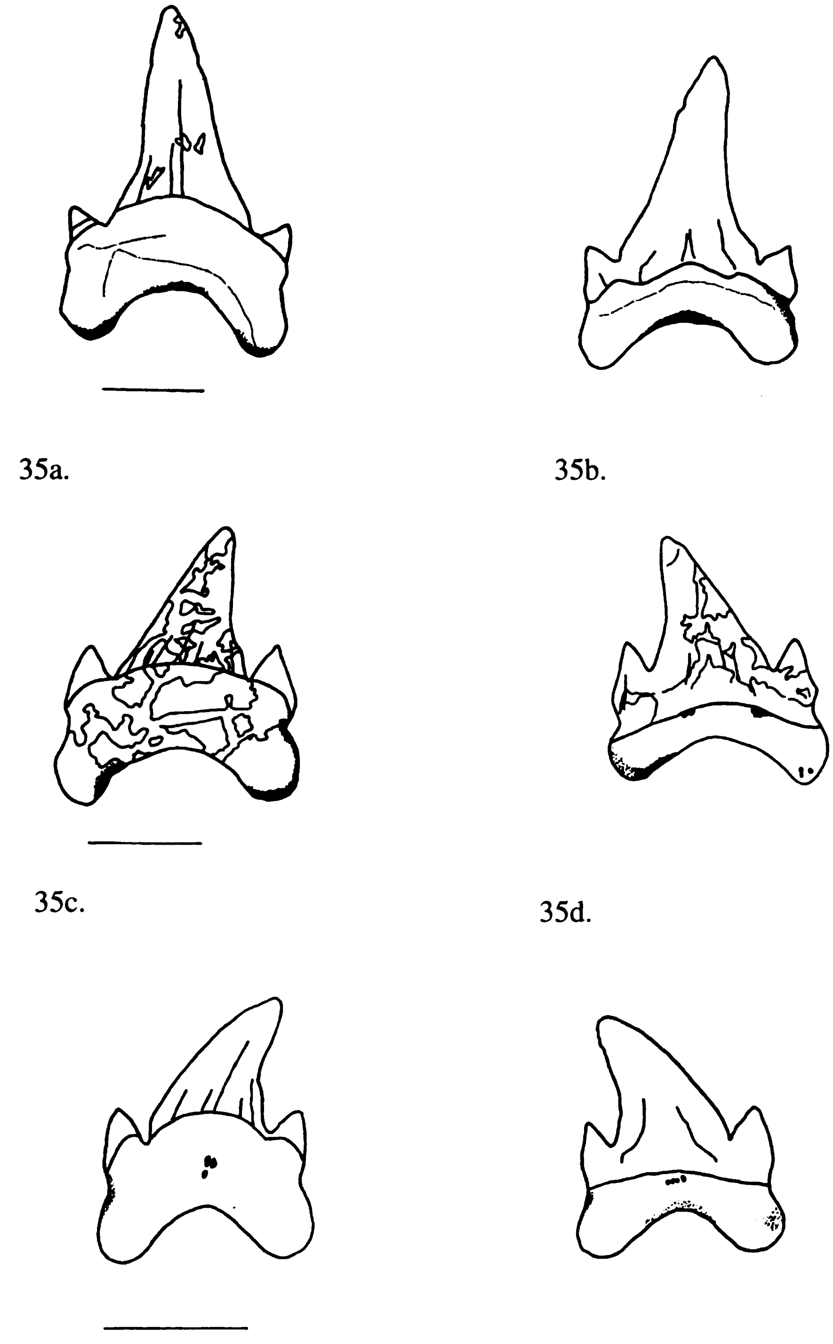


Figure 35. Drawings of *Archaeolamna kopingensis* teeth: almost pristine anterior tooth (a. lingual view, b. labial view), SMM P2003:8:7:1. Almost pristine anterior tooth with patchy coloration (c. lingual view, d. labial view), SMM P2003:8:7:2. Almost pristine lateral tooth (e. lingual view, f. labial view), SMM P2003:8:7:3. Scale bar = 5.0 mm.

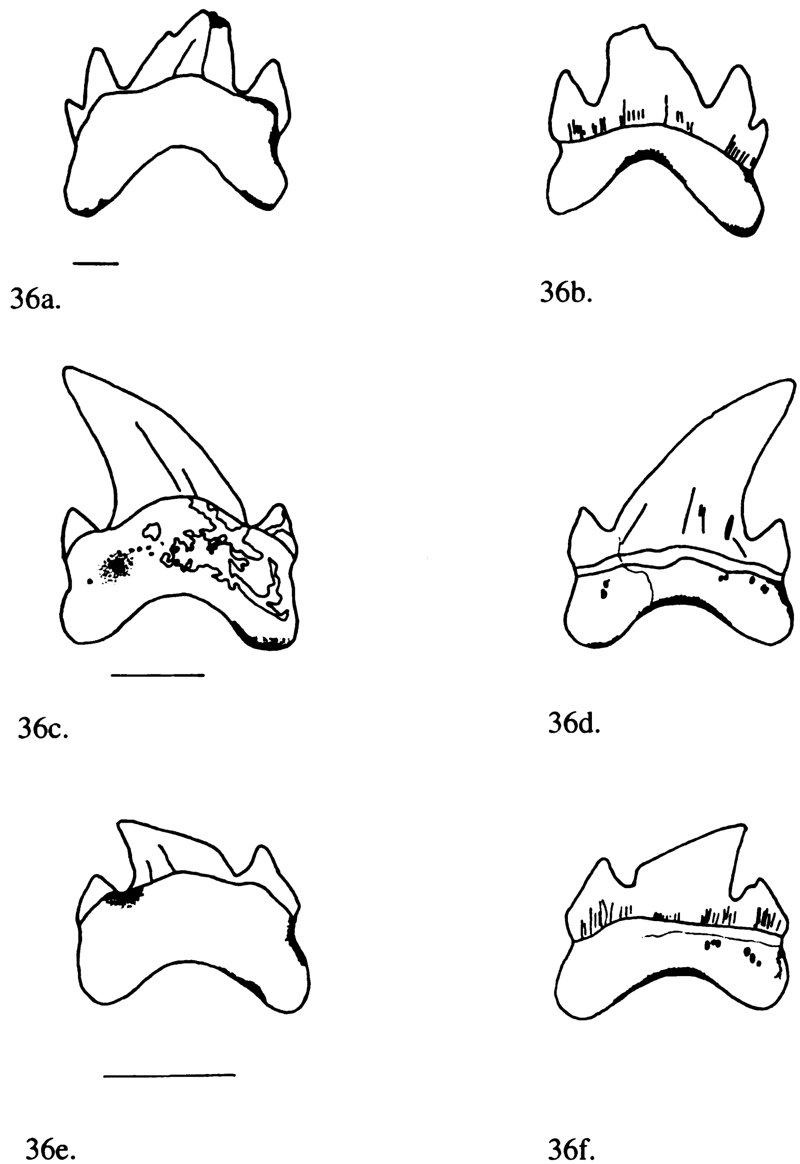


Figure 36. Drawings of *Archaeolamna kopingensis* teeth. Pristine but crown tip broken lateral tooth (a. lingual view, b. labial view), SMM P2003:8:7:4. Almost pristine lateral tooth with minimally abraded root (c. lingual view, d. labial view), SMM P2003:8:7:5. Almost pristine posterior tooth (e. lingual view, f. labial view), SMM P2003:8:7:6. Scale bar = 1.0 mm a-b and 5 mm c-f.

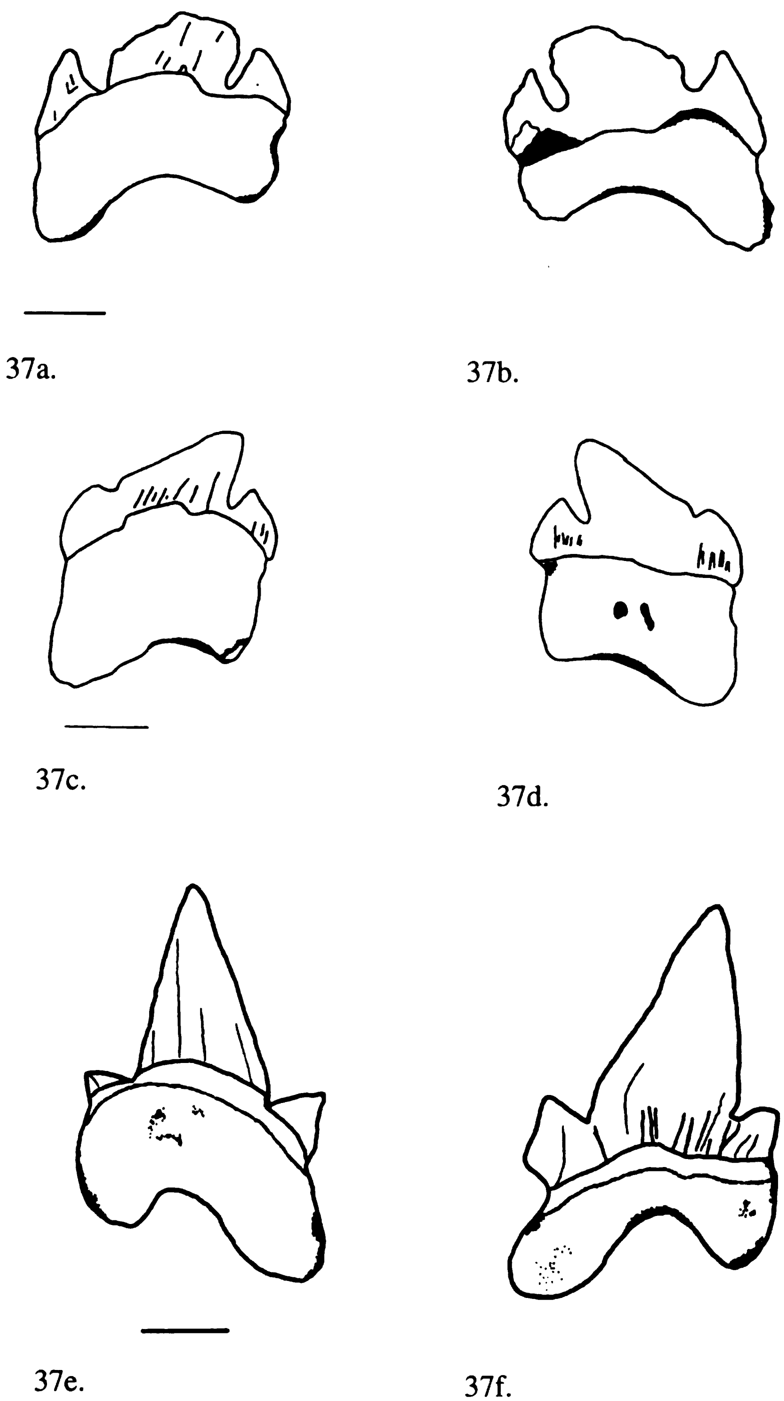
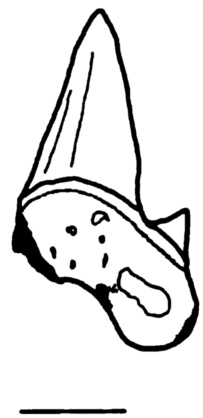
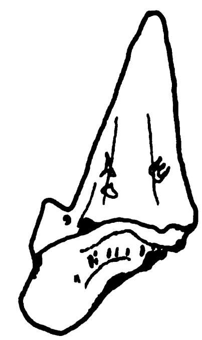


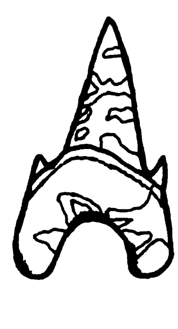
Figure 37. Drawings of *Archaeolamna kopingensis* teeth. Pristine but broken tip posterior tooth (a. lingual view, b. labial view), SMM P2003:8:7:7. Almost pristine posterior tooth (c. lingual view, d. labial view), SMM P2003:8:7:8. Pristine anterior tooth (e. lingual view, f. labial view), SMM P2006:13:7:1. Scale bar = 1.0 mm a-d and 5.0 mm e-f.



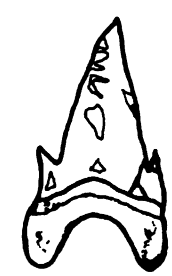
38a.



38b.

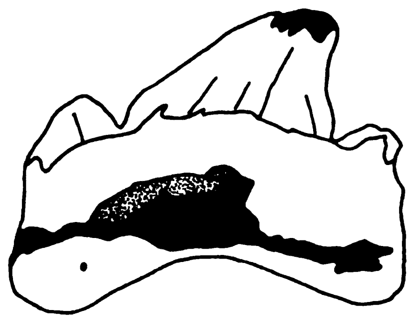


38c.

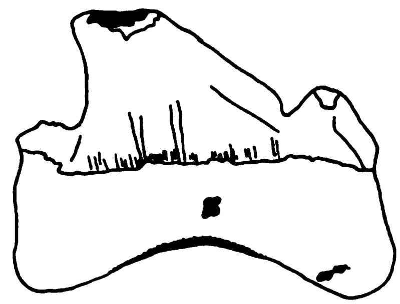


38d.

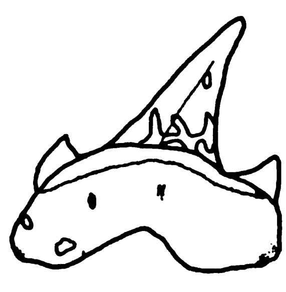
Figure 38. Drawings of *Archaeolamna kopingensis* teeth. Pristine (but broken) anterior tooth (a. lingual view, b. labial view), SMM P2006:13:7:2. Pristine anterior tooth with patchy coloration (c. lingual view, d. labial view), SMM P2006:13:7:3. Scale bar = 5.0 mm a-d.



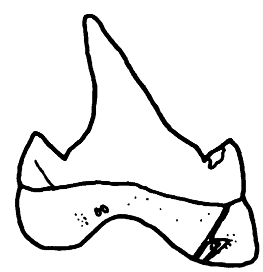
39a.



39b.

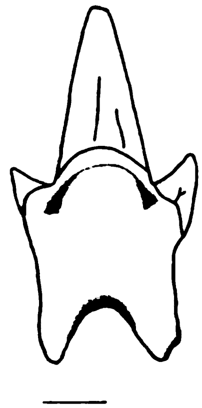


39c.



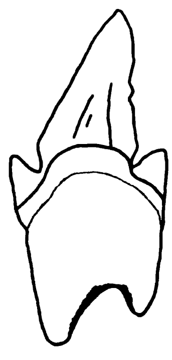
39d.

Figure 39. Drawings of *Cretolamna appendiculata* teeth (a. lingual view, b. labial view), SMM P2003:8:9:1 and (c. lingual view, d. labial view), SMM P2006:13:9:1. Scale bar = 5.0 mm a-d.

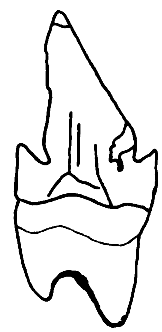


40a.

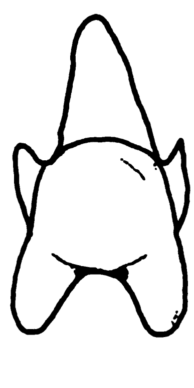
40b.



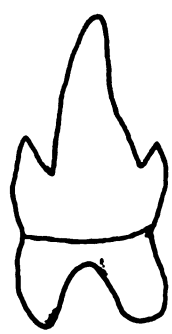
40c.



40d.



40e.

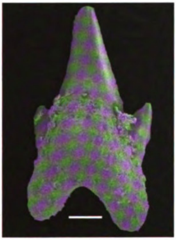


40f.

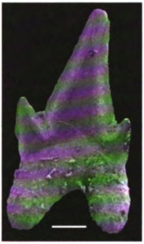
Figure 40. Drawings of *Protolamna sokolovi* teeth (a. lingual view, b. labial view), SMM P2003:8:8:1, (c. lingual view, d. labial view), SMM P2003:8:8:2, and (e. lingual view, f. labial view), SMM P2006:13:8:1. Scale bar = 1.0 mm a-f.

41a.

41b.

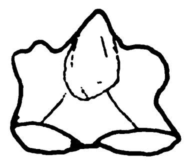


41c.

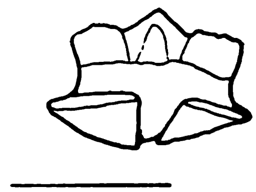


41d.

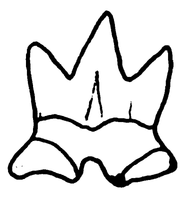
Figure 41. Drawings of *Protolamna sokolovi* teeth (a. lingual view, b. labial view), SMM P2006:13:8:2. SEMs of *Protolamna sokolovi* tooth (c. lingual view, d. labial view), SMM P2003:8:8:3. Scale bar = 1.0 mm a-d.



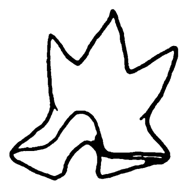
42a.



42b.



42c.



42d.

Figure 42. Drawings of *Archaeotriakis rochelleae* teeth (a. lingual view, b. labial view), SMM P2006:13:23:1 and (c. lingual view, d. labial view), SMM P2006:13:23:2. Scale bar = 1.0 mm a-d.

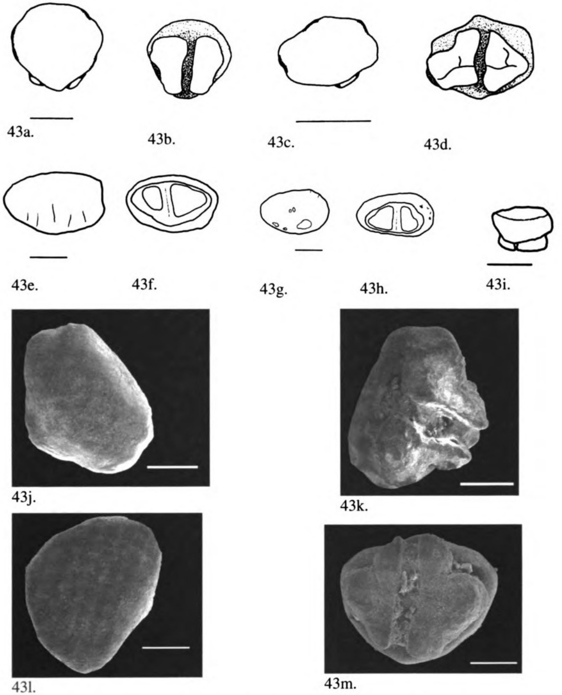
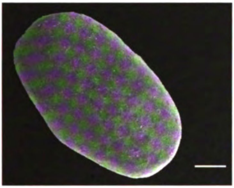
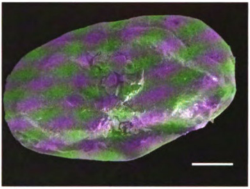


Figure 43. Drawings of *Protoplatyrhina renae* teeth (a. occlusal view, b. basal view), SMM P2003:8:11:1; (c. occlusal view, d. basal view), SMM P2003:8:11:2; (oblong/oval shape) (e. occlusal view, f. basal view), SMM P2006:13:11:1; (oblong/oval shape) (g. occlusal view, h. basal view), SMM P2006:13:11:2, and (i. profile view), SMM P2006:13:11:3. SEMs of *Protoplatyrhina renae* teeth (e. occlusal view, f. basal view), SMM P2003:8:11:3; (g. occlusal view, h. basal view) SMM P2003:8:11:4. Scale bar = 1.0 mm for a-k and 0.5 mm for l-m.

44a. 44b. 44c. 44d.



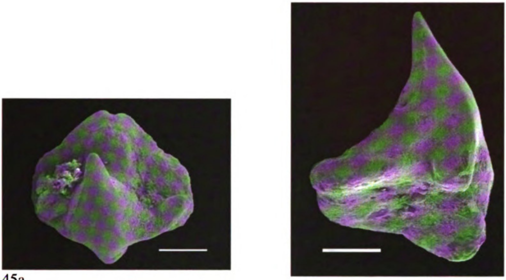
44e.



44f.

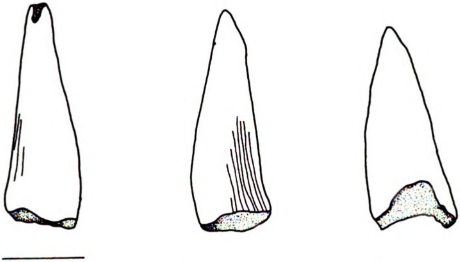
44g. 44h. 44i.

Figure 44. Drawings of *Protoplatyrhina renae* (weak sided shape) tooth (a. occlusal view, b. basal view), SMM P2003:8:11:13. Drawings of *Protoplatyrhina renae* (oblong/oval shape) tooth (c. occlusal view, d. basal view), SMM P2003:8:11:10. SEMs of *Protoplatyrhina renae* (oblong/oval shape) tooth (e. occlusal view, f. basal view), SMM P2003:8:11:11. Drawings of *Protoplatyrhina renae* dermal denticles (g. occlusal view, h. profile view), SMM P2003:8:11:15 and (i. occlusal view), SMM P2006:13:11:6. Scale bar = 1.0 mm a-d, and g-i, and 0.5 mm for e-f.



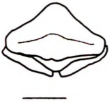
45a. 45b.

Figure 45. SEMs of *Squatirhina sp*. tooth (a. occlusal, b. lateral/basal view), SMM P2003:8:13:1. Scale bar = 1.0 mm a-b.



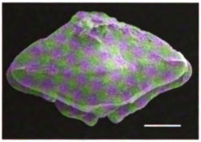
46a. 46b. 46c.

Figure 46. Drawings of *Ischyrhiza mira* rostral teeth (a-c, rostral teeth), SMM P2003:8:14:1, SMM P2003:8:14:2, SMM P2003:8:14:3. Scale bar = 5.0 mm a-c.

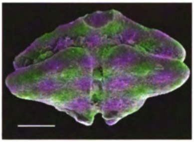


47a.

47b.

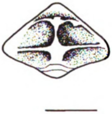


47c.



47d.

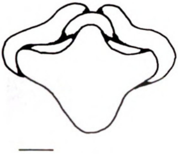
Figure 47. Drawings of *Ptychotrygon hooveri* tooth (a. occlusal view, b. basal view), SMM P2003:8:15:1. SEMs of *Ptychotrygon hooveri* tooth (c. occlusal view, d. basal view), SMM P2003:8:15:2. Scale bar = 1.0 mm a-b and 0.5 mm for c-d.



48a.

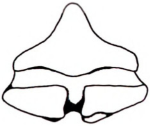
48b.

Figure 48. Drawings of *Ptychotrygon triangularis* tooth (a. occlusal view, b. basal view), SMM P2003:8:16:1. Scale bar = 1.0 mm a-b.

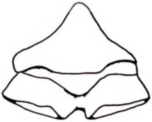


49a.

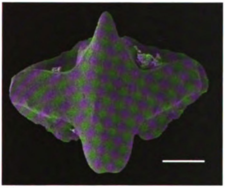
49b.



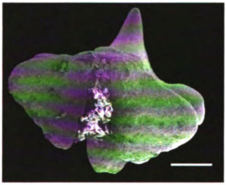
49c.



49d.

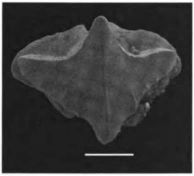


49e.

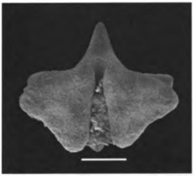


49f.

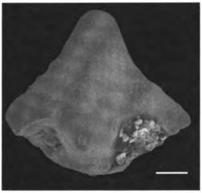
Figure 49. Drawings of Sclerorhynchidae tooth (a. occlusal view, b. basal view, c. lingual view, d. labial view), SMM P2003:8:17:1. SEMs of Sclerorhynchidae tooth (e. occlusal view, f. basal view), SMM P2003:8:17:2. Scale bar = 1.0 mm a-f.



50a.

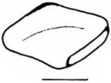


50b.

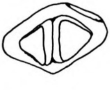


50c.

Figure 50. SEMs of Sclerorhynchidae teeth (a. occlusal view, b. basal view), SMM P2003:8:17:3 and (c. labial view), SMM P2003:8:17:4. Scale bar = 1.0 mm a-b and 0.5 mm for c.

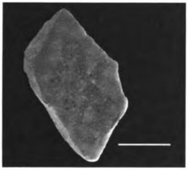


51a.

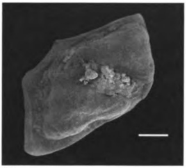


51b.

51c.



51d.



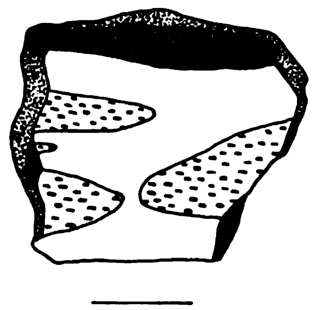
51e.

51f.

51g.

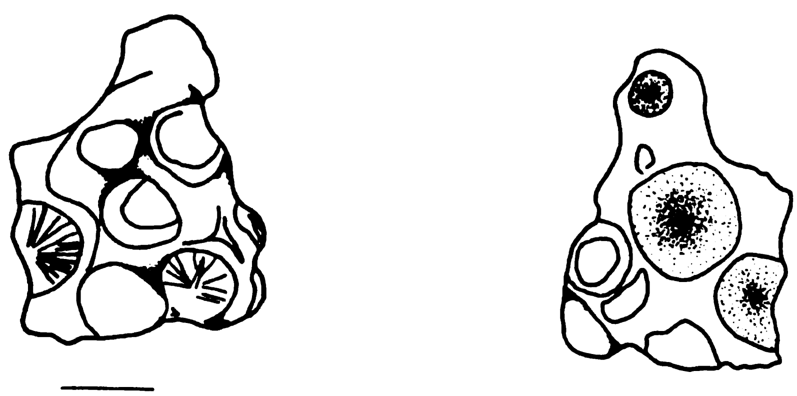
51h.

Figure 51. Drawings of *Myledaphus bipartitus* tooth (a. occlusal view, b. basal view, c. lateral view), SMM P2003:8:18:1. SEMs of *Myledaphus bipartitus* tooth (d. occlusal view, e. basal view), SMM P2003:8:18:2. Drawing of *Myledaphus bipartitus* tooth (f. lateral view), SMM P2006:13:16:1. Drawings of dermal denticle of *M. bipartitus* (g. occlusal view, h. lateral view), SMM P2003:8:18:4. Scale bar = 1.0 mm a-d, f, 0.5 mm e, and 5.0 mm for g-h.



52.

Figure 52. Drawing of partial *Ischyodus* (chimaerid) toothplate, SMM P2003:8:23:1. Scale bar = 5.0 mm.



53a. 53b.

Figure 53. Drawings of *Paralbula casei* pharyngeal tooth plate (a. occlusal view, b. basal view), SMM P2003:8:24. Scale bar = 1.0 mm a-b.

CHAPTER THREE

BIOGEOGRAPHY OF CONTEMPORANEOUS FAUNAS IN THE WESTERN INTERIOR SEAWAY, NORTH AMERICA

The Judith River Formation (JRF) fauna in this study is moderately diverse, consisting of 18 different taxa from the Woodhawk Bonebed (WH). Most of the taxa are identifiable to the species level but some only to the generic or familial level. The Power Plant Ferry Bonebed (PPF) consists of 16 different taxa, again with most of the taxa identifiable to species but a few only to the genus or family. The combined fauna of the present study and Case's work (1978a and 1979) consists of 26-28 identifiable taxa. Together, the WH and PPF bonebed faunas are mostly lamniforms and rajiforms that inhabited a shallow marine/estuarine environment of the Western Interior Seaway (WIS). Some of these species are typically considered cosmopolitan with a wide geographic spread, while others are restricted to North America or to the JRF of Montana. The WH and PPF faunas represent a rather typical chondrichthyan community and can be compared to a number of other contemporary faunas from the Late Cretaceous WIS. Very little work has been done on biogeography of chondrichthyans. In fact, any studies done have been qualitative in nature to date (Chiplonkar and Badve, 1968; Antunes, 1972; Soler-Gijón and López-Martínez, 1998; Cavin et al, 2000; Underwood and Rees, 2002; and Cuny at al, 2008). This will be the first quantitative study of Late Cretaceous WIS chondrichthyan biogeography.

Initial faunal comparisons within the JRF

The chondrichthyan fauna of the JRF, Montana based on Sahni (1972), Case (1978a and 1979), and this study is based on the taxa listed in Table 1. Sahni (1972) only noted an occurrence of *Myledaphus bipartitus* as his study concentrated on terrestrial taxa. Case's work (1978a and 1979) lists a total of 19 species of chondrichthyans, and one taxon identified only to genus. The present study has 20 taxa (16 species, 3 identified only to genus, and 1 identified only to family) of chondrichthyans. Approximately half of the taxa found by Case were not present in the WH or PPF samples, whereas six species or genera (ignoring those that have a degree of uncertainty in identification) collected in those samples and studied here are new for the JRF of Montana. The six taxa new to the JRF are *Squalicorax pristodontus*, *Cretolamna appendiculata*, *Protolamna sokolovi*, *Ischyrhiza avonicola*, *Ptychotrygon hooveri*, *P. triangularis*, and the genus *Squatirhina*.

The principal question that arises from these differences is whether the difference in taxonomic composition is due to sampling or intrinsic a/biotic factors. Perhaps there has been more sorting and more concentration of fossil material in this particular area. Sahni's (1972) sole taxon was from one site in the JRF. The specimens studied by Case in the late 1970's were collected from 10 different sites, employing different modes of collection from collecting float, to directly sampling scours or lenses (as in this study). Case's (1978a and 1979) material comes largely from Blaine County. The WH specimens used here are all from a locality off the Woodhawk Creek in Fergus County, south of the Missouri River (Figure 25). The PPF bulk sample is also from a single locality off of Power Plant Ferry Road south of the Missouri River (Figure 25) in Fergus

County. The scours (residual lag deposits) from which the teeth derived represent an accumulation of fossils in a hollow scour at the bottom of an estuary or other shallow marginal marine setting. Upon further examination, cluster analysis and Parsimony Analysis of Endemicity (PAE) (both discussed later) of the JRF and other faunas demonstrate that the combined JRF fauna is a homogeneous one and similar to many contemporaneous faunas from the WIS.

Biogeography of Elasmobranchs of the WIS

Cretaceous elasmobranchs are known from a number of Upper Cretaceous formations in western North America. Chimaerids are excluded here as they are seldom referenced in faunal studies. Based on the similar geography and substrate of the paleoenvironments of other faunas within the WIS, it is hypothesized that the combined data to create the JRF fauna is of similar size and composition to those contemporaneous faunas in the WIS. It is also hypothesized that the JRF fauna will differ from those faunas that are from more distant geographic location and less similar in substrate reflecting paleoenvironments. It is also hypothesized that any faunal differences between different faunas, but specifically between different studies within the same formation (JRF) are the result of local paleoenvironmental differences and not due to sampling. Data from a number of different sites and formations that fall within the Late Cretaceous WIS of North America were included in this study for comparison.

Boundaries for faunal comparison

Faunas and formations utilized for comparison derive from the Cenomanian to the Maastricthian, and from Alberta, Saskatchewan, Montana, South Dakota, North Dakota, Utah, Wyoming, Nebraska, Kansas, Colorado, Oklahoma, Arizona, New Mexico, and Texas (Figure 54). Studies on these fauna (see Table 2) in addition to the JRF of Montana include: the Hell Creek Formation (Maastrichtian) of Montana (Estes et al., 1969); the Lance Formation (Late Maastrichtian) of Wyoming (Estes, 1964), the Carlile Shale (Turonian) (Evetts, 1979), and the "Mesaverde" Formation (Upper Campanian) (Case, 1987) of Wyoming; the Carlile Shale (Turonian) (Cappetta, 1973 and Evetts, 1979) and the Greenhorn Formation (middle Cenomanian to middle Turonian) (Cicimurri, 2001) of South Dakota; the Hell Creek Formation (Maastrichtian) (Hoganson and Murphy, 2002) of North Dakota; the Fort Hays Limestone Member of the Niobrara Chalk (early Coniacian) (Shimada, 1996) and the Blue Hill Member of the Carlile Shale (middle Turonian) (Shimada, 2006) of Kansas; the Greenhorn Limestone (middle Cenomanian) of Colorado (Shimada et al., 2006); the Greenhorn Cyclothem (Cenomanian to Turonian) (Williamson et al., 1993) of Arizona; and multiple localities representing several formations covering the Cenomanian to Maastrichtian (Cappetta and Case, 1975b; Case and Cappetta, 1997; Cappetta and Case, 1999; and Welton and Farish, 1993) of Texas. Formations in Canada include the Judith River Formation (Campanian) (Brinkman, 1990) and Dinosaur Park Formation (upper Campanian) (Beavan and Russell, 1999) of Alberta, and the Judith River Formation (Campanian) (Eberth et al., 1990) and the Niobrara Formation (Coniacian) (Case et al. 1990) of Saskatchewan. Data compiled from these formations are summarized in Table 2 with a generalized correlation of formations and units in Figure 55 to aid in spatial and temporal visualization.

Similar paleoenvironments

Studies by Estes (1964) on the Lance Formation of Wyoming, Estes et al. (1969) on the Hell Creek Formation of Montana, Case (1987) on the "Mesaverde" Formation in Wyoming, Beavan and Russell (1999) on the Dinosaur Park Formation of Alberta, Eberth et al. (1990) on the Judith River Formation of Saskatchewan, Hoganson and Murphy (2002) on the Hell Creek Formation of North Dakota, and Cicimurri (2001) on the Greenhorn Formation of South Dakota, show that they all have a similar paleoenvironment to that of the JRF of Montana: a nearshore, estuarine habitat, as evidenced by the presence of invertebrates such as the oyster *Ostrea* and sequence stratigraphy as noted by Hayden (1860), with possibly a mixture of fresh water (supposed freshwater skates) and marine taxa (sharks, skates and rays, and marine teleosts). With similar environments and ages the expectation would be that similar faunas would be present in each formation. Initial impressions show that "Mesaverde" has the greatest species diversity (32 different elasmobranchs found) among these formations with similar paleoenvironments.

JRF and "Mesaverde" Formation comparison

Using the combined JRF faunal data of Case (1978a and 1979) and the present work on WH and PPF as a base for comparison to these other faunas, the compiled data shows that the "Mesaverde" of Wyoming (Case, 1987) shows the greatest similarity in fauna to the JRF with 13 matches (Table 3): *Hybodus montanensis*, *Chiloscyllium missouriensis*, *Cretorectolobus olsoni*, *Eucrossorhinus microcuspidatus*, *Hypotodus grandis*, *Archaeolamna kopingensis*, *Squalicorax kaupi*, *Squalicorax pristodontus*, *Archaeotriakis rochellleae*, *Protoplatyrhina renae*, *Ischyrhiza avonicola*, *I. mira*, and *Myledaphus bipartitus*.

<u>JRF and Hell Creek (MT) and Lance Formations comparisons</u>

The Lance Formation of Wyoming and Hell Creek Formation of Montana each have four species with Hell Creek (MT) sharing three species with Montana (JRF) (Table 4): *Squatirhina* sp., *Ischyrhiza avonicola*, and *Myledaphus bipartitus* and two species from the Lance Formation match: *Ischyrhiza avonicola* and *Myledaphus bipartitus* (Table 4). The Hell Creek (MT) and Lance formations do share an additional taxon not found in the JRF, *Lissodus selachos* (Table 4).

<u>JRF and Dinosaur Park, JRF (AB), JRF (SK), and Niobrara (SK) Formations comparisons</u>

The Dinosaur Park Formation of Alberta, despite only having 10 species, has eight matches with Montana (Table 5), *Hybodus montanensis*, *Cretorectolobus olsoni*, *Eucrossorhinus microcuspidatus*, *Archaeolamna kopingensis*, *Protoplatyrhina renae*, *Ischyrhiza mira*, *Ptychotrygon blainensis*, and *Myledaphus bipartitus*. Only two species are found in the JRF (AB), *Hybodus montanensis* and *Myledaphus bipartitus*, both of which are found in the JRF (MT). *Myledaphus bipartitus* was the only common constituent between Montana and the JRF (SK) (1 taxon total), and no taxa were shared with the Niobrara Formation (eight taxa total); despite being geographically close, the Niobrara (Coniacian) is older than the JRF and shows no similarity in fauna (Table 6).

JRF and Hell Creek (ND) and Greenhorn Formations comparisons

The Hell Creek Formation of North Dakota, which represents a shallow marine environment with estuaries, bays, and channels (Hoganson and Murphy, 2002) has three species that match the Montana JRF elasmobranchs (Table 7): *Cretolamna appendiculata*, *Ischyrhiza* sp., and *Myledaphus bipartitus*. The Greenhorn Formation of South Dakota only shows one species out of the 19 found that matched the JRF of Montana, *Cretolamna appendiculata* (Table 8).

Among the more geographically and temporally close formations, the "Mesaverde" in Wyoming shows the most similarity to the JRF faunas from Montana, and also the highest overall diversity, followed by the eight species shared with the Dinosaur Park Formation in Alberta. The other formations show less similarity, with anywhere from one to three species shared.

Additional Observations

The accumulated data can also be utilized to interpret the temporal and geographical spans of some of the species from the WH and PPF bonebeds. The longest ranging species in time is *Cretolamna appendiculata* (ranging from the Albian to the Ypresian [Cappetta, 1987]) and it also has the largest geographical range (France, Australia, east coast of North America, the American southwest, and north-central North America). *C.*

appendiculata is often considered a cosmopolitan species with a world-wide distribution. Because of its distribution it is worth noting that Case (1978a and 1979) found no occurrence of *C. appendiculata* in Montana or in Wyoming even though it is found in the Dakotas, Wyoming (Evetts, 1979), and in the southwest (Williamson et al., 1993).

Other cosmopolitan species from WH and PPF include *Squalicorax kaupi* (known from Europe, Japan, New Zealand, Madagascar [Gottfried et al., 2001], the east coast of North America, the American southwest, north central North America [Cappetta, 1987], and Angola [Antunes and Cappetta, 2002]) and *Ischyodus* (*I. bifurcatus* -- Russia, Belgium, the Gulf of Mexico coast, the east and west coasts of North America, and Montana [Cappetta, 1987]). *Squalicorax pristodontus* is also widely distributed with a range that includes the Netherlands, Morocco, Texas, Montana, New Jersey (Cappetta, 1987) and Angola (Antunes and Cappetta, 2002). Other wide-ranging taxa include *Archaeolamna kopingensis* (Sweden, Australia, east coast of North America and the Montana region [Case, 1978a; Siverson, 1996; and Kemp, 1991]), *Myledaphus bipartitus* (north central North America, and the former Soviet Union [Cappetta, 1987]), and *Protolamna sokolovi* (the former Soviet Union, France, and North America [Cappetta, 1987], with the new occurrence in Montana [this report] further expanding the range).

The remaining species have ranges that are largely restricted to North America, and in some cases just to the JRF of Montana and neighboring formations. *Hypotodus grandis* is found only in Montana and Wyoming with no other occurrences reported (Case 1978a and 1987); *Protoplatyrhina renae*, while found outside of Montana and Wyoming (Case, 1978a and 1987), is only found in North America (Alberta and Texas). Both *Ischyrhiza mira* and *Ischyrhiza avonicola* occur only in North America; however, within North America they have wide geographic ranges. Prior to this study *Ptychotrygon hooveri* was only found in Texas; however its geographic and temporal range can be extended to the Campanian of Montana. *Protolamna sokolovi* also has a sparse record, being found in the early Cretaceous of France, Russia, and Texas (Cappetta, 1987). Its presence in the JRF represents a major temporal range expansion. *Hybodus montanensis* is found primarily in Montana, *Cretorectolobus olsoni* has a wide range in North America with an occurrence in France, and *Ptychotrygon triangularis* is found throughout central North America and also in the former Czechoslovakia (Cappetta, 1987) or modern day Czech Republic.

Geographically restricted species such as *Hypotodus grandis* (and to a lesser extent *Protoplatyrhina renae*, *Ischyrhiza mira*, and *I. avonicola*), based on current knowledge, appear to be endemic forms, being found in one region and formation and nowhere else. They may truly be limited to the JRF or it is possible that they have not as yet been found in other localities around the world. Another possibility is that they have been described and classified as entirely different species. This is possible because identifications have been made on the basis of single disassociated teeth, which as discussed earlier pose problems.

Hierarchical Cluster Analysis and Parsimony Analysis of Endemicity (PAE)

To expand the analytical scope of the faunal comparisons, the data from Table 2 were converted to a spreadsheet (0-absent, 1-present) with the columns representing presence and absence of genera (for genus level analysis) (Appendix A) and species (for species level analysis) (Appendix B), and the rows local areas/formations in the WIS. Hierarchical cluster analysis of the matrix was initially carried out using a hierarchical cluster analysis with Simpson's coefficient of faunal similarity (paired group method), first described in Simpson (1943: footnote 5). Parsimony Analysis of Endemicity (PAE) (Rosen and Smith, 1988 and Fortey and Cocks, 1992) was carried out with the heuristic (TBR) algorithm with Wagner optimization. The hierarchical cluster analysis tests the faunal similarity between local area/formations whereas PAE measures the endemicity of species and infers barriers or selective differentiation. The PAE clusters the formations based on their shared endemic taxa. Both the cluster analysis and PAE were completed with PAleontological STatistics (PAST) (Hammer et al., 2001).

<u>Cluster Analysis of WIS genera (R-mode analysis)</u>

In Figures 56-59 six of the WIS genera (taxa marked with an asterisk), *Odontaspis*, *Cretorectolobus*, *Eucrossorhinus*, *Hypotodus*, *Archaeotriakis*, and *Synechodus* co-occur with a similarity index of 1 on this tree in bracket 1 (Figure 57). These are also the genera with first discovery in the JRF of Montana (Case, 1978a) with the exception of *Hypotodus*. The rest of the genera found in the JRF (taxa marked with an asterisk) are distributed throughout the rest of bracket 1 and the other two brackets (Figures 58 and

59) of the tree. At each provincial level the similarity has dropped to 0.38, 0.48, and 0.6 for these clusters.

Cluster Analysis of WIS genera (Q-mode analysis)

Looking at the same data transposed (Q-mode analysis) (Figure 60), the JRF (marked with an asterisk) is most similar, with an index of 1, to the JRF of Alberta in bracket 2. It is also quite similar (0.95) to the Dinosaur Park Formation in Alberta. The overall topology of the tree also suggests that there are two clusters of local areas, possibly indicative of a barrier that relates to the differentiation in species.

Figure 56 (R-mode analysis) was broken into 3 brackets for ease of display. However, for proper analysis brackets 1 and 2 should be considered as one. That creates 2 main brackets or clusters within Figure 56 that map onto the 2 clusters in Figure 60 (Q-mode analysis). The JRF ("P" in Figure 60) correlates with the combined bracket of 1 and 2 that contains the majority of the JRF genera.

Cluster Analysis of WIS species (R-mode analysis)

Cluster analysis at the species rank (Figures 61-65) is similar to that at the generic level but re-focuses on the JRF species. The analysis shows a clustering of the JRF species, with 17 of the taxa grouped together at a similarity index of 1 in bracket 3 (Figure 64). The clustered species are: *Hybodus montanensis*, *H. storeri*, *Synechodus andersoni*, *S. striatus*, *Cretorectolobus olsoni*, *Eucrossorhinus microcuspidatus*, *Hypotodus grandis*, *Hypotodus* spp., *Odontaspis sanguinei*, *Archaeolamna kopingensis*, *Archaeotriakis* *rochelleae*, *Protoplatyrhina renae*, *Squatirhina* sp., *Ischyrhiza mira*, *Ptychotrygon blainensis*, Sclerorhynchidae indet., and *Myledaphus bipartitus*. *Squalicorax kaupi*, *S. pristodontus*, and *Chiloscyllium missouriensis* show a similarity of 0.84. The least similar grouping of the JRF are *Ptychotrygon triangularis*, *P. hooveri*, *Protolamna sokolovi*, *Ischyrhiza* sp., and *Cretolamna appendiculata* which show a similarity of 0.3 in bracket 2 (Figure 63) and the last species, *Ischyrhiza avonicola* shows a similarity index of 0.48 in bracket 4 (Figure 65).

Cluster Analysis of WIS species (Q-mode analysis)

Transposing the data (Figure 66) the overall topology of the Q-mode tree resembles that seen in Figure 60. Despite the overall similarity, adding a species-level analysis has changed the results (taxa and JRF marked with an asterisk). This change in grouping may be the result of taxonomic splitting, potentially creating more species than may actually exist and skewing the results. Another possibility is that ambiguously identified species (as is stated in the literature) were grouped with other species, identified with fair certainty or ambiguously identified, further skewing the results. Before, at the generic level, the JRF of Montana grouped with the JRF of Alberta with an index of 1. Here in Figure 66 it now groups with the Hell Creek Formation of Montana and the Judith River Formation of Saskatchewan with a similarity of 0.9 in bracket 2 (Figure 66). Two clusters are present, as in Figure 60, though the makeup of each cluster has shifted slightly.

Figure 61 (R-mode analysis) was broken into 4 brackets for ease of display. However, for proper analysis brackets 1 and 2 should be considered as one, as should brackets 3 and 4. That creates 2 main brackets or clusters within Figure 61 that map on to the 2 clusters in Figure 66 (Q-mode analysis). The JRF ("Q" in Figure 66) correlates with the combined bracket of 1 and 2, however it is the combined bracket of 3 and 4 that contains the majority of the JRF species. Upon further examination, many of the JRF taxa in the combined bracket of 3 and 4 occur in multiple formations, and it is possible that with the collapsing of this data to just the genera as in the previous trees of Figures 56-59 some resolution is lost, thus making it appear that many of the taxa are endemic to the JRF but instead may be endemic to the end of the Cretaceous of the WIS when investigated at the species level. Another contributing factor may be that some of the taxa are not identified solely to species and have been "lumped" with other ambiguous taxa. This leads to further loss of resolution.

Cluster Analysis Implications

The JRF fauna at both the generic and species levels show endemism for some of the taxa. Six genera cluster together, co-occurring and show a macro-ecological association or biome of the genera in time and space and a similarity index of 1 (bracket 1) on the tree (Figure 56). These genera are: *Odontaspis*, *Cretorectolobus*, *Eucrossorhinus*, *Hypotodus*, *Archaeotriakis*, and *Synechodus*. The remainder of the genera are less similar, implying more cosmopolitanism as they are distributed throughout the other two brackets of the tree.

The species cluster analysis (Figure 61) also suggests endemism but with the addition of the species there are a greater number of endemic taxa, with 17 plotting at a similarity index of 1 in bracket 3 (Figure 64). The endemic taxa are: *Hybodus montanensis*, *H. storeri*, *Synechodus andersoni*, *S. striatus*, *Cretorectolobus olsoni*, *Eucrossorhinus microcuspidatus*, *Hypotodus grandis*, *Hypotodus* spp., *Odontaspis sanguinei*, *Archaeolamna kopingensis*, *Archaeotriakis rochelleae*, *Protoplatyrhina renae*, *Squatirhina* sp., *Ischyrhiza mira*, *Ptychotrygon blainensis*, Sclerorhynchidae indet., and *Myledaphus bipartitus*. Three species less clustered at a level that implies semi-endemism (similarity index 0.84), *Squalicorax kaupi*, *S. pristodontus*, and *Chiloscyllium missouriensis*. The least similar grouping of JRF taxa are spread over the remainder of the tree and imply that they are the most cosmopolitan forms: *Ptychotrygon triangularis*, *P. hooveri*, *Protolamna sokolovi*, *Ischyrhiza* sp., and *Cretolamna appendiculata* group with a similarity of 0.3 in bracket 2 (Figure 63). The last species is the semi-cosmopolitan taxon *Ischyrhiza avonicola*, which shows a degree of cosmopolitanism with a similarity index of 0.48 in bracket 4 (Figure 65).

Two distinct clusters are present in each of the trees (Figures 60 and 66). One possible explanation for this division is a geographical or (more explicitly) a latitudinal separation. Another possibility is a temporal division. Regarding a latitudinal separation, the more southerly formations (left side of the trees) would likely have formed in warmer locales as many are carbonates such as the limestones in Kansas and Colorado. This is different from the more northern formations that would have been from cooler locales and tend to be more siliciclastic in nature such as the shales of Wyoming and South Dakota. This difference in substrate composition is indicative of the environment; chalky formations tend to form in shallow warm waters, and the clastic bottoms are closer to land and are also shallow warm waters but more marginal marine. If, on the other hand the division is temporal, the left cluster shows older faunas as the formations span the Cenomanian to the Santonian, and the right cluster (which includes the JRF), spans the Campanian and Maastrichtian. Both latitudinal and temporal differences are plausible explanations, and together may be responsible for this dichotomy in the distribution of WIS elasmobranch taxa.

PAE of genera

Figure 67 is the PAE of the genera for the collected data. Any genus that had only one occurrence was removed from the analysis as were any formations that contained less than 10 taxa. The formations and genera that remained were used for the PAE (data in Appendix C). The resulting strict consensus tree shows three distinct geographic groupings or provinces. Provinces are according to Anstey et al. (2003) are,

> A large geographic area biotically distinct and separated by physical or climatic barriers from adjacent provinces. Endemic taxa constitute 25–50% of the provincial biota. Synonym of region (Hallam 1994).

PAE of species

Figure 69 is the PAE of the species for the collected data. The data received the same treatment as the generic data, any species with only one occurrence was removed from the analysis as were any formations that contained less than 10 taxa. The formations and species that remained were used for the PAE (data in Appendix D). The resulting strict consensus tree shows two distinct groupings that are temporally grouped together.

Implications of PAE

The JRF genera on the PAE tree (strict consensus) plot within their own geographic region in Figures 67 and 68. The JRF forms a province (Province 1 which will be referred to as the Judith River Formation Province) with the Dinosaur Park Formation in Alberta, the "Mesaverde" Formation in Wyoming, and the Hell Creek Formation in North Dakota, implying that these four formations share more endemic genera with each other than with the other formations. The Texas groups bracket together in their own province (Province 2, referred to as the Texas Province) with Arizona, and Colorado and South Dakota form a third province (Province 3, referred to as the Greenhorn Province). These provinces likely represent ecoregions, not only sharing endemic faunas but also similar environments with the northern province being more clastic, muddy matrix from being closer to the source terrain, and the southern provinces being warmer, more marine settings with calcareous deposits.

The JRF species on the PAE (strict consensus) tree do not plot within their geographic region but within a temporal space in Figures 69 and 70. They are grouped with the "Mesaverde" Formation of Wyoming (Campanian), the Taylor Group of Texas (Campanian), and the Navarro Group of Texas (Maastrichtian) all at the end of the Late Cretaceous (province 3, referred to as the Judith River Formation Province). The other formations are all older, spanning the Cenomanian to the Santonian with the Texas

Province (bracket 2) consisting of three of the Texas groups and Arizona, and bracket 1 (Greenhorn Province) consisting South Dakota and Colorado. The addition of the species in this PAE seems to override any geographic grouping of shared endemic species, again possibly due to "splitting" of species, and instead groups taxa temporally into provinces.

Cluster Analysis of JRF by study

Initial observations and comparisons of the studies by Case (1978a and 1979) and the present study revealed differences in the faunal compositions as well as a difference in faunal composition between the two sites (WH and PPF). These differences have been tentatively attributed to localized areas of variable energy, creating sorting (Tulu, 2007) and/or a sampling issue. When a cluster analysis of the entire JRF data is performed based on the individual studies, this current study and Case's combined work (1978a and 1979), the species new to the JRF found in this study cluster together. It would thus appear that the similarities between Case's work, and this new study, are quite low. However, the same cluster analysis shows a 0.5 similarity in the taxa from the Case studies (1978a and 1979) and this current study. When the combined data of the JRF (Case, 1978a and 1979, and this new study) are used in a cluster analysis and PAE for the WIS, the JRF groups with similarly sized faunas of the same age and relative geographic region. Sampling is a likely factor in explaining the differences in faunal composition between Case (1978a and 1979) and this study. Case collected from 10 sites, either surface float or directly from the matrix, and this work used bulk sampling from two sites.

The slight differences between WH and PPF seem to be due to subtle differences in paleoenvironmental conditions in each area that may in turn affect the composition of the respective faunas. The sites are both lag deposits consisting of the same shoreface deposits and stratigraphic horizon, and are only about 3 kilometers from each other. Compositionally the faunas are very similar (Table 9), with four species at WH (*Hybodus montanensis*, *Squatirhina* sp., *Ischyrhiza avonicola*, and *Ischyodus*) missing from PPF, and two species at PPF that are missing from WH (*Squalicorax pristodontus* and *Archaeotriakis rochelleae*).

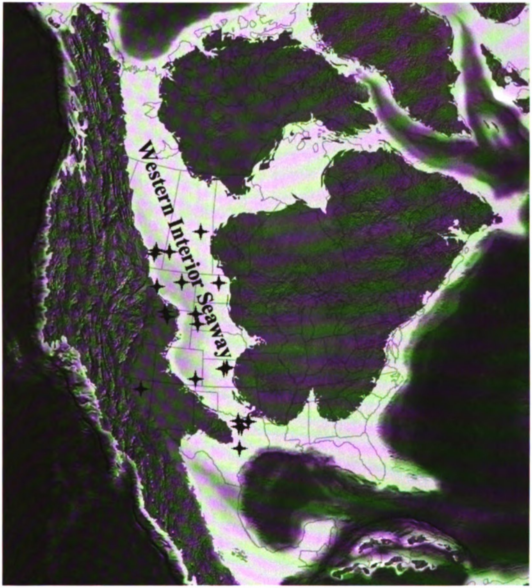


Figure 54. Western Interior Seaway (WIS) 75 Ma (approximate age of the JRF in Montana) - geographical focus for JRF faunal comparisons with local areas/formations of this study roughly positioned (modified from Blakey, 2009).

Table 2. Judith River Formation (Montana) fauna compared to the faunas from formations in Montana, Wyoming, North Dakota, South Dakota, Colorado, Alberta, Saskatchewan, Kansas, Arizona, and Texas. Data were compiled from the current study in addition to Sahni, 1972, Case, 1978a, and 1979 to create the JRF (Montana) data set. Additional WIS data comes from: Case, 1987, Case and Cappetta, 1997, Case et al., 1990, Cappetta and Case, 1975b and 1999, Cappetta, 1973, Estes, 1964, Estes et al., 1969, Evetts, 1979, Brinkman, 1990, Eberth et al., 1990, Williamson et al. 1993, Beavan and Russell, 1999, Cicimurri, 2001, Hoganson and Murphy, 2002, Welton and Farish, 1993, Shimada, 1996, Shimada, 2006, and Shimada et al., 2006. x = occurrence of taxon in formation.

* denotes grouping of additional and/or problematic identifications within the family, genus, or species as listed below:

1. Included are *Ptychodus mammilaris* and *Ptychodus* cf. *mammilaris*
2. Included are *Ptychodus rugosus* and *Ptychodus* cf. *rugosus*
3. Included are *Chiloscyllium greeni* and *Chiloscyllium* aff. *greeni*
4. Included are *Cretorectolobus olsoni* and *Cretorectolobus* cf. *olsoni*
5. Included are *Cantioscyllium decipiens* and *Cantioscyllium* aff. decipiens
6. Included are *Carcharias amonensis* and *Carcharias* aff. *amonensis*
7. Included are *Johnlongia parvidens* and *Johnlongia* cf. *parvidens*
8. Included are *Scapanorhynchus raphiodon* and *Scapanorhynchus* cf. *raphiodon*
9. Included are *Scapanorhynchus* sp. and cf. *Scapanorhynchus* sp.
10. Included are *Archaeolamna kopingensis* and *Archaeolamna* cf. *kopingensis*
11. Includes *Cretodus semiplicatus* and *C. crassidens* (a junior synonym of *C. semiplicatus*) after Schwimmer et al. (2002)
12. Included are *Protolamna sokolovi* and *Protolamna* aff. *sokolovi*
13. Included are *Pseudocorax granti* and *Pseudocorax* aff. *granti*
14. Included are *Squalicorax kaupi* and *Squalicorax* sp., cf. *S. kaupi*
15. Included are *Ischyrhiza avonicola* and *Ischyrhiza* cf. *avonicola*
16. Included are *Ptychotrygon blainensis* and *Ptychotrygon* aff. *blainensis* and *Ptychotrygon* cf. *blainensis*
17. Included are *Ptychotrygon texana* and *Ptychotrygon* cf. *P. texana*
18. Included are Sclerorhynchidae indet. and Sclerorhynchidae (?) incertae sedis

Order	Family	Taxon	Judith River Formation MT	Hell Creek Formation MT	"Mesaverde Formation" WY	Lance Formation WY	Hell Creek Formation ND	Carlile Shale SD	Greenhorn Formation SD	Greenhorn Limestone CO	Judith River Formation AB	Dinosaur Park Formation AB	Judith River Formation SK	Niobrara Formation SK	Carlile Shale Formation KS	Niobrara Chalk KS	Greenhorn Cyclothem AZ	Woodbine Group TX	Eagle Ford Group TX	Austin Group TX	Taylor Group TX	Navarro Group TX
Hybodontiformes																						
	Hybodontidae	Hybodus montanensis	x		x						x	x										
		Hybodus storeri	x																			
		Hybodus wyomingensis			x																	
		Hybodus sp.															x	x	x	x		
		Hybodus sp. 1																x				
		Hybodus sp. 2																x				
		Hybodus sp. 3																	x	x		
	Polyacrodontidae	Lissodus aff. babulskii																				x
		Lissodus griffisi			x																	
		Lissodus selachos		x		x															x	
		Lissodus sp.																x				
		Lissodus spp.																x			x	x
		Polyacrodus illingsworthi																	x			
	Ptychodontidae	Ptychodus anonymus						x	x	x					x				x			
		Ptychodus connellyi																		x		
		Ptychodus decurrens							x	x							x	x	x	x		
		Ptychodus latissimus																	x	x	x	
		Ptychodus mammilaris*[1]															x		x	x		
		Ptychodus mortoni														x			x	x		
		Ptychodus occidentalis							x	x									x			

		Judith River Formation MT	Hell Creek Formation MT	"Mesaverde Formation" WY	Lance Formation WY	Hell Creek Formation ND	Carlile Shale SD	Greenhorn Formation SD	Greenhorn Limestone CO	Judith River Formation AB	Dinosaur Park Formation AB	Judith River Formation SK	Niobrara Formation SK	Carlile Shale Formation KS	Niobrara Chalk KS	Greenhorn Cyclothem AZ	Woodbine Group TX	Eagle Ford Group TX	Austin Group TX	Taylor Group TX	Navarro Group TX
	Ptychodus polygyrus						x											x			
	Ptychodus rugosus *2												x					x	x		
	Ptychodus whipplei						x	x						x		x		x	x		
	Ptychodus sp.							x											x		
Hexanchiformes																					
Hexanchidae	Hexanchus microdon																			x	x
	Hexanchus sp.																				x
Squaliformes																					
Squalidae	Centrophoroides worlandensis			x																	
	Squalus huntensis																				x
	Squalus sp.																			x	x
	Somniosinae (subfamily)																			x	
	Etmopterinae (subfamily)																			x	
Squatiniformes																					
Squatinidae	Squatina hassei																			x	x
Synechodontiformes																					
Palaeospinacidae	Synechodus andersoni	x																			
	Synechodus illingworthi?						x														
	Synechodus striatus	x																			
	Synechodus turneri			x																	

Table 2 continued.

Table 2 continued.

		Judith River Formation MT	Hell Creek Formation MT	"Mesaverde Formation" WY	Lance Formation WY	Hell Creek Formation ND	Carlile Shale SD	Greenhorn Formation SD	Greenhorn Limestone CO	Judith River Formation AB	Dinosaur Park Formation AB	Judith River Formation SK	Niobrara Formation SK	Carlile Shale Formation KS	Niobrara Chalk KS	Greenhorn Cyclothem AZ	Woodbine Group TX	Eagle Ford Group TX	Austin Group TX	Taylor Group TX	Navarro Group TX
	Synechodus sp.						x														
Heterodontiformes																					
Heterodontidae	Heterodontus cf. canaliculatus																		x	x	
	Heterodontus granti																				x
	Heterodontus sp.																	x	x		
Orectolobiformes																					
Hemiscyllidae	Chiloscyllium greeni *3															x	x	x	x	x	
	Chiloscyllium missouriensis	x		x																	
	Chiloscyllium sp.															x					
Orectolobidae	Brachaelurus bighornensis			x																	
	Brachaelurus greeni						x														
	Cretorectolobus olsoni *4	x		x							x										x
	Cretorectolobus sp.																x	x			
	Eucrossorhinus microcuspidatus	x		x							x										
Ginglymostomatidae	Cantioscyllium decipiens *5						x										x	x	x		
	Cantioscyllium meyeri																			x	x
	Cantioscyllium sp.																x				
	Ginglymostoma globidens			x																	
	Ginglymostoma sp.																				x
	Nebrius sp.																				x

Table 2 continued.

		Judith River Formation MT	Hell Creek Formation MT	"Mesaverde Formation" WY	Lance Formation WY	Hell Creek Formation ND	Carlile Shale SD	Greenhorn Formation SD	Greenhorn Limestone CO	Judith River Formation AB	Dinosaur Park Formation AB	Judith River Formation SK	Niobrara Formation SK	Carlile Shale Formation KS	Niobrara Chalk KS	Greenhorn Cyclothem AZ	Woodbine Group TX	Eagle Ford Group TX	Austin Group TX	Taylor Group TX	Navarro Group TX
	Plicatoscyllium antiquum																				x
	Plicatoscyllium derameei																			x	x
Rhincodontidae	?Rhincodontidae																	x			
Parascylliidae	Pararhincodon groessenssi																			x	
	Pararhincodon aff. lehmani																x				
	cf. Pararhincodon sp.								x												
Lamniformes																					
Odontaspididae	Carcharias amonensis*6							x									x	x			
	Carcharias heathi																				x
	Carcharias holmdelensis																				x
	Carcharias cf. samhammeri																				x
	Carcharias saskatchewanensis							x	x												
	Carcharias steineri										x										
	Carcharias tenuiplicatus							x	x								x				
	Carcharias sp.					x		x													
	Carcharias sp. 1																				x
	Carcharias sp. A																	x			
	Carcharias sp. B																			x	x
	Cenocarcharias tenuiplicatus																x				
	Hypotodus grandis	x		x																	
	Hypotodus spp.	x																			

Table 2 continued.

		Judith River Formation MT	Hell Creek Formation MT	"Mesaverde Formation" WY	Lance Formation WY	Hell Creek Formation ND	Carlile Shale SD	Greenhorn Formation SD	Greenhorn Limestone CO	Judith River Formation AB	Dinosaur Park Formation AB	Judith River Formation SK	Niobrara Formation SK	Carlile Shale Formation KS	Niobrara Chalk KS	Greenhorn Cyclothem AZ	Woodbine Group TX	Eagle Ford Group TX	Austin Group TX	Taylor Group TX	Navarro Group TX
	Johnlongia parvidens*7						x	x	x												
	cf. Johnlongia sp.								x												
	Odontaspis aculeatus										x										x
	Odontaspis amonensis																x				
	Odontaspis cheathami			x																	
	Odontaspis sanguinei	x																			
	Odontaspis saskatchewanensis												x								
	Odontaspis steineri			x																	
	Odontaspis tenuiplicatus																x				
	Odontaspis sp.					x															
	Pseudodontaspis herbsti			x																	
	Synodontaspis lilliae												x								
Mitsukurinidae	Anomotodon toddi																				x
	Scapanorhynchus aff. praeraphiodon																x				
	Scapanorhynchus raphiodon*8						x	x								x		x	x		
	Scapanorhynchus texanus			x																x	x
	Scapanorhynchus sp.*9													x	x						x
	Scapanorhynchus sp. or Carcharias sp.																			x	
Cretoxyrhinidae	Archaeolamna kopingensis*10	x		x					x		x										
	Cretodus semiplicatus*11						x	x	x					x		x	x	x	x		

		Judith River Formation MT	Hell Creek Formation MT	"Mesaverde Formation" WY	Lance Formation WY	Hell Creek Formation ND	Carlile Shale SD	Greenhorn Formation SD	Greenhorn Limestone CO	Judith River Formation AB	Dinosaur Park Formation AB	Judith River Formation SK	Niobrara Formation SK	Carlile Shale Formation KS	Niobrara Chalk KS	Greenhorn Cyclothem AZ	Woodbine Group TX	Eagle Ford Group TX	Austin Group TX	Taylor Group TX	Navarro Group TX
	Cretodus sp.												x								
	Cretolamna appendiculata	x				x	x	x	x					x	x	x	x	x	x	x	x
	Cretolamna maroccana																				x
	Cretolamna woodwardi															x		x			
	Cretolamna sp.																				x
	Cretoxyrhina mantelli							x	x				x		x	x		x	x		
	Dallasiella willistoni																	x	x		
	Leptostyrax macrorhiza																x				
	cf. Leptostyrax sp.															x					
	Paraisurus compressus																x				
	Protolamna carteri																x				
	Protolamna compressidens																	x	x		
	Protolamna sokolovi*12	x															x				
	Serratolamna serrata					x														x	x
Alopidae	Paranomotodon sp.					x									x				x	x	x
Anacoracidae	Microcorax crassus								x								x				
	Pseudocorax granti*13																	x	xx	x	x
	Squalicorax baharijensis																x				
	Squalicorax curvatus							x	x								x	x			
	Squalicorax falcatus						x	x	x				x	x	x	x	x	x	x		

Table 2 continued.

Table 2 continued.

		Judith River Formation MT	Hell Creek Formation MT	"Mesaverde Formation" WY	Lance Formation WY	Hell Creek Formation ND	Carlile Shale SD	Greenhorn Formation SD	Greenhorn Limestone CO	Judith River Formation AB	Dinosaur Park Formation AB	Judith River Formation SK	Niobrara Formation SK	Carlile Shale Formation KS	Niobrara Chalk KS	Greenhorn Cyclothem AZ	Woodbine Group TX	Eagle Ford Group TX	Austin Group TX	Taylor Group TX	Navarro Group TX
	Squalicorax kaupi *14	xx		x																x	x
	Squalicorax pristodontus	x		x																x	x
	Squalicorax volgensis							x													
	Squalicorax sp.								x									x			
	Squalicorax sp. 1																	x	x		
	Squalicorax sp. 2																	x	x		
Carcharhiniformes																					
	Carcharhiniformes incertae sedis								x												
Scyliorhinidae	Scyliorhinus arlingtonensis																x				x
	Scyliorhinus ivagrantae																				x
	Scyliorhinus taylorensis																			x	
	Scyliorhinus tensleepensis			x																	
	Scyliorhinidae																x	x	x	x	x
Triakidae	Archaeotriakis ornatus			x																	
	Archaeotriakis rochelleae	x		x																	
	Galeorhinus aff. girardoti																				x
	Galeorhinus sp.					x														x	x
	Palaeogaleus navarroensis																				x
	Palaeogaleus sp.																			x	x
	Squatigaleus sulphurensis																				x
	Triakidae or Carcharinidae indet. gen.																				x

Table 2 continued.

		Judith River Formation MT	Hell Creek Formation MT	"Mesaverde Formation" WY	Lance Formation WY	Hell Creek Formation ND	Carlile Shale SD	Greenhorn Formation SD	Greenhorn Limestone CO	Judith River Formation AB	Dinosaur Park Formation AB	Judith River Formation SK	Niobrara Formation SK	Carlile Shale Formation KS	Niobrara Chalk KS	Greenhorn Cyclothem AZ	Woodbine Group TX	Eagle Ford Group TX	Austin Group TX	Taylor Group TX	Navarro Group TX
Rajiformes																					
Hypsobatidae	Protoplatyrhina hopii															x					
	Protoplatyrhina renae	x		x							x										x
	Pseudohypolophus mcnultyi															x	x	x			
	?Pseudohypolophus sp.					x											x				
Rhinobatidae	Rhinobatos casieri			x																x	
	Rhinobatos craddocki																				x
	Rhinobatos incertus							x										x	x		
	?Rhinobatos incertus sp.						x														
	Rhinobatos kiestensis																	x	x		
	Rhinobatos ladoniaensis																			x	
	Rhinobatos lobatus																	x	x		
	Rhinobatos uvulatus																				x
	Rhinobatos sp.						x		x				x			x		x	x		
	Squatirhina americana				x																
	Squatirhina roessingi			x																	
	Squatirhina sp.	x	x																		
	?Squatirhina sp.																x				
Rajidae	Raja farishi																				x
	Rajidae																			x	x
Sclerorhynchidae	Ankistrorhynchus washakiensis			x																	

		Judith River Formation MT	Hell Creek Formation MT	"Mesaverde Formation" WY	Lance Formation WY	Hell Creek Formation ND	Carlile Shale SD	Greenhorn Formation SD	Greenhorn Limestone CO	Judith River Formation AB	Dinosaur Park Formation AB	Judith River Formation SK	Niobrara Formation SK	Carlile Shale Formation KS	Niobrara Chalk KS	Greenhorn Cyclothem AZ	Woodbine Group TX	Eagle Ford Group TX	Austin Group TX	Taylor Group TX	Navarro Group TX
	?Ganopristinae						x														
	Hamrabatis weltoni																				x
	Ischyrhiza avonicola *15	xx	x	x	x		x									x				x	x
	Ischyrhiza basinensis			x																	
	Ischyrhiza mira	x		x							x									x	x
	Ischyrhiza monasterica																				x
	Ischyrhiza schneideri															x		x	x		
	Ischyrhiza texana																	x	x	x	x
	Ischyrhiza sp.	x				x															
	Kiestus texanus																	x	x		
	Onchopristis dunklei															x	x	x	x		
	Onchosaurus pharo																			x	
	Ptychotrygon agujaensis																			x	
	Ptychotrygon blainensis *16	x									x									x	
	Ptychotrygon boothi			x																	
	Ptychotrygon ellae			x																	
	Ptychotrygon greybullensis			x																	
	Ptychotrygon hooveri	x															x	x	x		
	Ptychotrygon ledouxi						x														
	Ptychotrygon rubyae															x					

Table 2 continued.

Table 2 continued.

		Judith River Formation MT	Hell Creek Formation MT	"Mesaverde Formation" WY	Lance Formation WY	Hell Creek Formation ND	Carlile Shale SD	Greenhorn Formation SD	Greenhorn Limestone CO	Judith River Formation AB	Dinosaur Park Formation AB	Judith River Formation SK	Niobrara Formation SK	Carlile Shale Formation KS	Niobrara Chalk KS	Greenhorn Cyclothem AZ	Woodbine Group TX	Eagle Ford Group TX	Austin Group TX	Taylor Group TX	Navarro Group TX
	Ptychotrygon slaughteri																x				
	Ptychotrygon texana [*17]					x															x
	Ptychotrygon triangularis	x					x									x	x	x	x	x	x
	Ptychotrygon vermiculata																				x
	Ptychotrygon winni																				x
	Ptychotrygon sp.								x												
	Schizorhiza cf. weileri																				x
	Sclerorhynchus fanninensis																			x	
	Sclerorhynchus pettersi																				x
	Sclerorhynchus priscus																	x	x		
	Sclerorhynchus sp.																		x	x	
	Sclerorhynchus sp. 1																			x	
	Sclerorhynchus sp. 2																	x	x		
	Texatrygon copei																			x	
	Texatrygon hooveri																	x	x		
	Sclerorhynchidae indet. [*18]	x							x												
Pristidae	Peyeria sp.					x															
Myliobatiformes																					
Dasyatidae	Coupatezia turneri																				x
	Dasyatis commercensis																				x
	Dasyatis spp.																x	x	x	x	x

		Judith River Formation MT	Hell Creek Formation MT	"Mesaverde Formation" WY	Lance Formation WY	Hell Creek Formation ND	Carlile Shale SD	Greenhorn Formation SD	Greenhorn Limestone CO	Judith River Formation AB	Dinosaur Park Formation AB	Judith River Formation SK	Niobrara Formation SK	Carlile Shale Formation KS	Niobrara Chalk KS	Greenhorn Cyclothem AZ	Woodbine Group TX	Eagle Ford Group TX	Austin Group TX	Taylor Group TX	Navarro Group TX
	?Dasyatidae																x				
	Myledaphus bipartitus	x	x	x	x	x				x	x	x									
	Texabatis corrugata																				x
	Family - ?Ganopristinae						x														
Myliobatidae	Brachyrhizodus wichitaensis																			x	
	Enantiobatis tarrantensis																x				
	Myliobatidae																			x	
Rhombodontidae	Rhombodus binkhorsti																				x
	Rhombodus ? sp.																				x
Mobulidae	Cretomanta canadensis							x	x				x					x	x		
Incertae sedis	Ewingia problematica																				x
	totals	26	4	32	4	11	19	19	21	2	10	1	8	6	6	21	39	49	42	43	63

Table 2 continued.

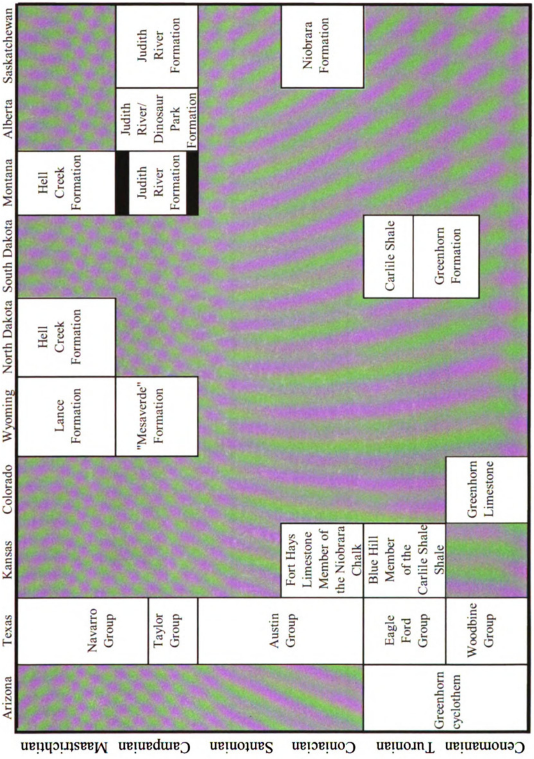


Figure 55. Generalized correlation chart of formations/units of the WIS in the study. JRF Montana is bracketed in black. Information gathered from studies cited in caption for Table 2.

Table 3. JRF fauna compared to "Mesaverde" Formation fauna. The two formations share 13 species (large, bold "**X**").

	JRF MT	"Mesaverde Formation" WY
Hybodus montanensis	X	X
Hybodus storeri	x	
Hybodus wyomingensis		x
Lissodus griffisi		x
Centrophoroides worlandensis		x
Synechodus andersoni	x	
Synechodus striatus	x	
Synechodus turneri		x
Chiloscyllium missouriensis	X	X
Brachaelurus bighornensis		x
Cretorectolobus olsoni	X	X
Eucrossorhinus microcuspidatus	X	X
Ginglymostoma globidens		X
Hypotodus grandis	X	X
Hypotodus spp.	x	
Odontaspis cheathami		x
Odontaspis sanguinei	x	
Odontaspis steineri		x
Pseudodontaspis herbsti		x
Scapanorhynchus texanus		x
Archaeolamna kopingensis	X	X
Cretolamna appendiculata	x	
Protolamna sokolovi	x	
Squalicorax kaupi	X	X
Squalicorax sp., cf. S. kaupi	x	
Squalicorax pristodontus	X	X
Scyliorhinus tensleepensis		x
Archaeotriakis ornatus		x
Archaeotriakis rochelleae	X	X
Protoplatyrhina renae	X	X
Rhinobatos casieri		x
Squatirhina roessingi		x
Squatirhina sp.	x	
Ankistrorhynchus washakiensis		x
Ischyrhiza avonicola	x	
Ischyrhiza cf. avonicola	X	X
Ischyrhiza basinensis		x
Ischyrhiza mira	X	X
Ischyrhiza sp.	x	
Ptychotrygon blainensis	x	
Ptychotrygon boothi		x
Ptychotrygon ellae		x
Ptychotrygon greybullensis		x
Ptychotrygon hooveri	x	
Ptychotrygon triangularis	x	
Sclerorhynchidae indet.	x	
Myledaphus bipartitus	X	X
totals	28	32

	JRF MT	Hell Creek Formation MT	Lance Formation WY
Hybodus montanensis	x		
Hybodus storeri	x		
Lissodus selachos		x	x
Synechodus andersoni	x		
Synechodus striatus	x		
Chiloscyllium missouriensis	x		
Cretorectolobus olsoni	x		
Eucrossorhinus microcuspidatus	x		
Hypotodus grandis	x		
Hypotodus spp.	x		
Odontaspis sanguinei	x		
Archaeolamna kopingensis	x		
Cretolamna appendiculata	x		
Protolamna sokolovi	x		
Squalicorax kaupi	x		
Squalicorax sp., cf. S. kaupi	x		
Squalicorax pristodontus	x		
Archaeotriakis rochelleae	x		
Protoplatyrhina renae	x		
Squatirhina americana			x
Squatirhina sp.	**X**	**X**	
Ischyrhiza avonicola	**X**	**X**	**X**
Ischyrhiza cf. avonicola	x		
Ischyrhiza mira	x		
Ischyrhiza sp.	x		
Ptychotrygon blainensis	x		
Ptychotrygon hooveri	x		
Ptychotrygon triangularis	x		
Sclerorhynchidae indet.	x		
Myledaphus bipartitus	**X**	**X**	**X**
totals	28	4	4

Table 4. JRF fauna compared to Hell Creek (MT) and Lance formations faunas. JRF shares 3 species with Hell Creek and 2 species Lance Formation with (large, bold "X").

	JRF MT	Dinosaur Park Formation AB	JRF AB
Hybodus montanensis	**X**	**X**	**X**
Hybodus storeri	x		
Synechodus andersoni	x		
Synechodus striatus	x		
Chiloscyllium missouriensis	x		
Cretorectolobus olsoni	**X**	**X**	
Eucrossorhinus microcuspidatus	**X**	**X**	
Carcharias steineri		x	
Hypotodus grandis	x		
Hypotodus spp.	x		
Odontaspis aculeatus		x	
Odontaspis sanguinei	x		
Archaeolamna kopingensis	**X**	**X**	
Cretolamna appendiculata	x		
Protolamna sokolovi	x		
Squalicorax kaupi	x		
Squalicorax sp., cf. S. kaupi	x		
Squalicorax pristodontus	x		
Archaeotriakis rochelleae	x		
Protoplatyrhina renae	**X**	**X**	
Squatirhina sp.	x		
Ischyrhiza avonicola	x		
Ischyrhiza cf. avonicola	x		
Ischyrhiza mira	**X**	**X**	
Ischyrhiza sp.	x		
Ptychotrygon blainensis	**X**	**X**	
Ptychotrygon hooveri	x		
Ptychotrygon triangularis	x		
Sclerorhynchidae indet.	x		
Myledaphus bipartitus	**X**	**X**	**X**
totals	28	10	2

Table 5. JRF fauna compared to Dinosaur Park and JRF (Alberta faunas). JRF shares 8 species with Dinosaur Park and 2 species with JRF Alberta (large, bold "**X**").

	JRF MT	Niobrara Formation SK	JRF SK
Hybodus montanensis	x		
Hybodus storeri	x		
Ptychodus rugosus		x	
Synechodus andersoni	x		
Synechodus striatus	x		
Chiloscyllium missouriensis	x		
Cretorectolobus olsoni	x		
Eucrossorhinus microcuspidatus	x		
Hypotodus grandis	x		
Hypotodus spp.	x		
Odontaspis sanguinei	x		
Odontaspis saskatchewanensis		x	
Synodontaspis lilliae		x	
Archaeolamna kopingensis	x		
Cretodus sp.		x	
Cretolamna appendiculata	x		
Cretoxyrhina mantelli		x	
Protolamna sokolovi	x		
Squalicorax falcatus		x	
Squalicorax kaupi	x		
Squalicorax sp., cf. S. kaupi	x		
Squalicorax pristodontus	x		
Archaeotriakis rochelleae	x		
Protoplatyrhina renae	x		
Rhinobatos sp.		x	
Squatirhina sp.	x		
Ischyrhiza avonicola	x		
Ischyrhiza cf. avonicola	x		
Ischyrhiza mira	x		
Ischyrhiza sp.	x		
Ptychotrygon blainensis	x		
Ptychotrygon hooveri	x		
Ptychotrygon triangularis	x		
Sclerorhynchidae indet.	x		
Myledaphus bipartitus	**X**		**X**
Cretomanta canadensis		x	
totals	28	8	1

Table 6. JRF fauna compared to JRF (Saskatchewan) and Niobrara Formation. The JRF (MT) shares only one species with the JRF Saskatchewan (large, bold "**X**") and no species with the Niobrara Formation.

	JRF MT	Hell Creek Formation ND
Hybodus montanensis	x	
Hybodus storeri	x	
Synechodus andersoni	x	
Synechodus striatus	x	
Chiloscyllium missouriensis	x	
Cretorectolobus olsoni	x	
Eucrossorhinus microcuspidatus	x	
Carcharias sp.		x
Hypotodus grandis	x	
Hypotodus spp.	x	
Odontaspis sanguinei	x	
Odontaspis sp.		x
Archaeolamna kopingensis	x	
Cretolamna appendiculata	**X**	**X**
Protolamna sokolovi	x	
Serratolamna serrata		x
Paranomotodon sp.		x
Squalicorax kaupi	x	
Squalicorax sp., cf. S. kaupi		
Squalicorax pristodontus	x	
Galeorhinus sp.		x
Archaeotriakis rochelleae	x	
Protoplatyrhina renae	x	
?Pseudohypolophus sp.		x
Squatirhina sp.	x	
Ischyrhiza avonicola	x	
Ischyrhiza cf. avonicola		
Ischyrhiza mira	x	
Ischyrhiza sp.	**X**	**X**
Ptychotrygon blainensis	x	
Ptychotrygon hooveri	x	
Ptychotrygon texana		x
Ptychotrygon triangularis	x	
Sclerorhynchidae indet.	x	
Peyeria sp.		x
Myledaphus bipartitus	**X**	**X**
totals	28	11

Table 7. JRF fauna compared to Hell Creek Formation ND fauna. The two formations share 3 species (large, bold "**X**").

	JRF MT	Greenhorn Formation SD
Hybodus montanensis	x	
Hybodus storeri	x	
Ptychodus anonymus		x
Ptychodus decurrens		x
Ptychodus occidentalis		x
Ptychodus whipplei		x
Ptychodus sp.		x
Synechodus andersoni	x	
Synechodus striatus	x	
Chiloscyllium missouriensis	x	
Cretorectolobus olsoni	x	
Eucrossorhinus microcuspidatus	x	
Carcharias amonensis		x
Carcharias saskatchewanensis		x
Carcharias tenuiplicatus		x
Carcharias sp.		x
Hypotodus grandis	x	
Hypotodus spp.	x	
Johnlongia parvidens		x
Odontaspis sanguinei	x	
Scapanorhynchus raphiodon		x
Archaeolamna kopingensis	x	
Cretodus semiplicatus		x
Cretolamna appendiculata	**X**	**X**
Cretoxyrhina mantelli		x
Protolamna sokolovi	x	
Squalicorax curvatus		x
Squalicorax falcatus		x
Squalicorax kaupi	x	
Squalicorax sp., cf. S. kaupi	x	
Squalicorax pristodontus	x	
Squalicorax volgensis		x
Archaeotriakis rochelleae	x	
Protoplatyrhina renae	x	
Rhinobatos incertus		x
Squatirhina sp.	x	
Ischyrhiza avonicola	x	
Ischyrhiza cf. avonicola	x	
Ischyrhiza mira	x	
Ischyrhiza sp.	x	
Ptychotrygon blainensis	x	
Ptychotrygon hooveri	x	
Ptychotrygon triangularis	x	
Sclerorhynchidae indet.	x	
Myledaphus bipartitus	x	
Cretomanta canadensis		x
totals	28	19

Table 8. JRF fauna compared to Greenhorn Formation fauna. The two formations share 1 species (large, bold "**X**").

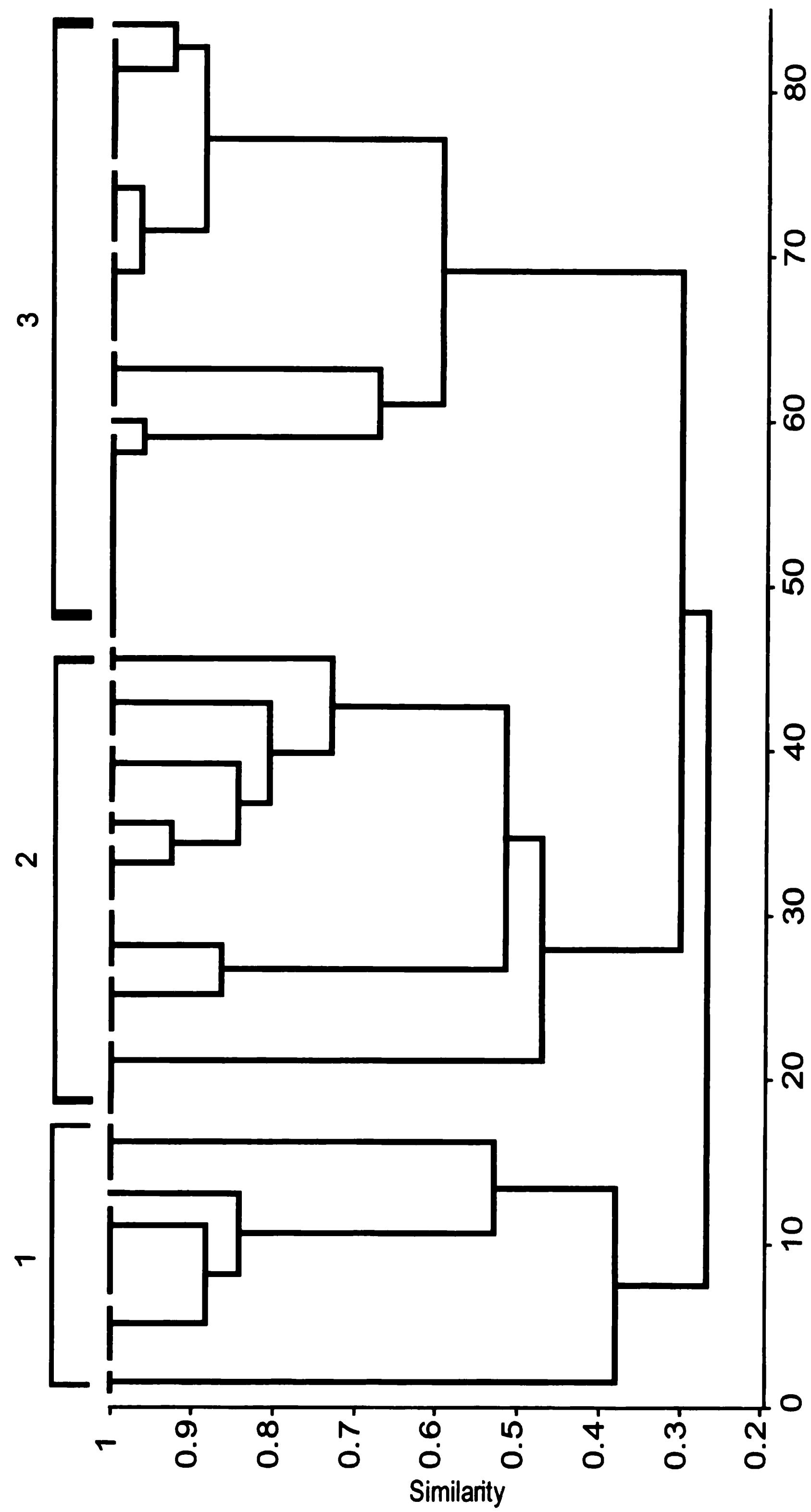


Figure 56. Cluster analysis of genera by formation from the WIS. Each bracketed cluster is illustrated in more detail in Figures 57-59.

Figure 57. Subset from figure 56, bracket 1. Cluster analysis of genera by formation from the WIS. *Synodontaspis* (A), *Odontaspis** (B*), *Cretorectolobus** (C*), *Eucrossorhinus** (D*), *Hypotodus** (E*), *Archaeotriakis** (F*), *Synechodus** (G*), *Centrophoroides* (H), *Brachaelurus* (I), *Pseudodontaspis* (J), *Ankistrorhynchus* (K), *Ischyrhiza** (L*), *Myledaphus** (M*), Sclerorhynchidae indet.* (N*), *Archaeolamna** (O*), Carcharhiniformes incertae sedis (P), and *Ptychotrygon** (Q*).

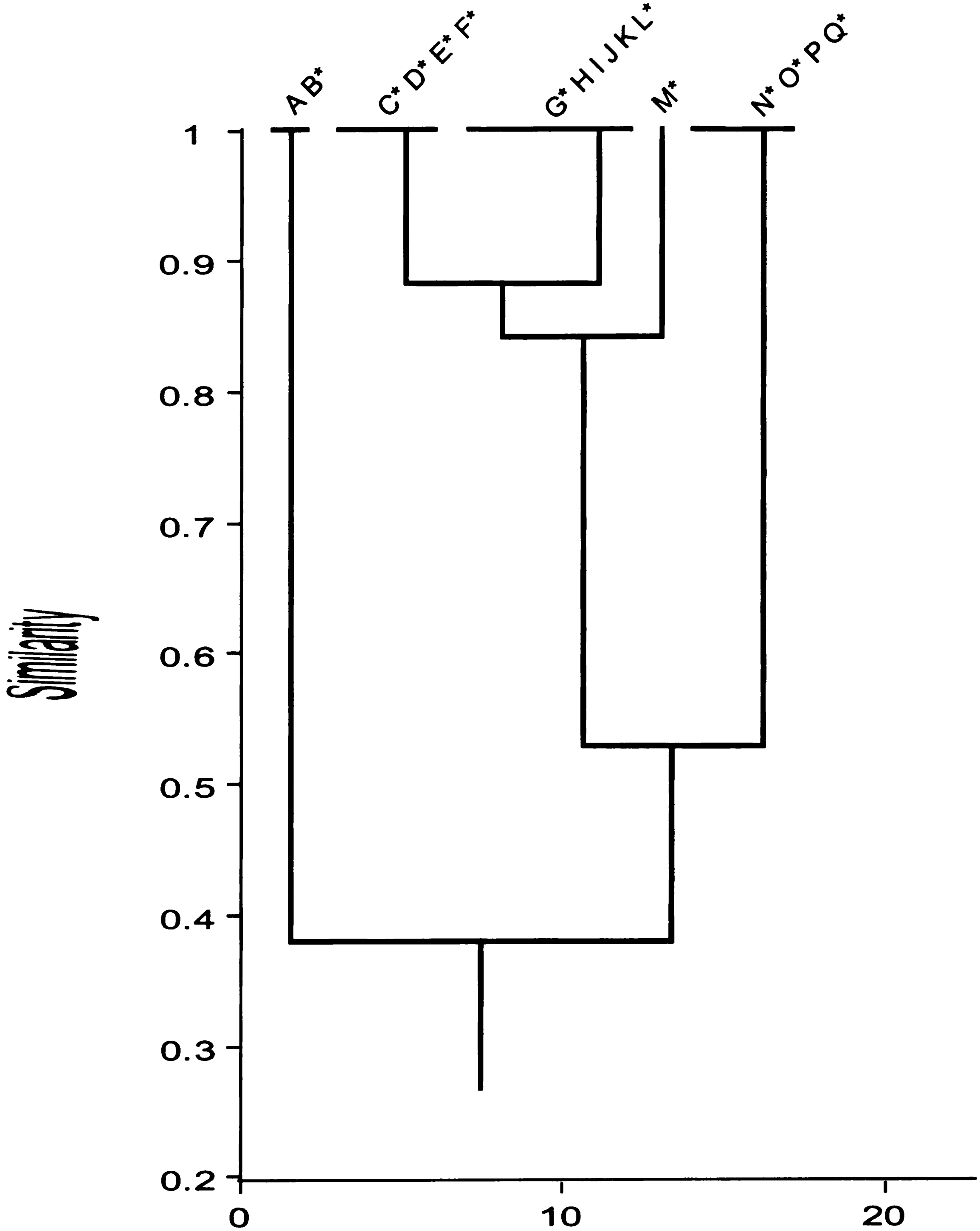

A B*
C* D* E* F*
G* H I J K L*
M*
N* O* P Q*
Similarity
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
10
20

Figure 58. Subset from figure 56, bracket 2. Cluster analysis of genera by formation from the WIS. *Johnlongia* (R), *Cretodus* (S), *Squalicorax** (T*), ?Ganopristinae (U), Family - ?Ganopristinae (V), *Cretoxyrhina* (W), *Dallasiella* (X), *Kiestus* (Y), *Cretomanta* (Z), *Protolamna** (AA*), *Polyacrodus* (AB), *Hybodus** (AC*), ?Rhincodontidae (AD), *Leptostyrax* (AE), *Scapanorhynchus* (AF), *Onchopristis* (AG), *Enantiobatis* (AH), *Pseudohypolophus* (AI), *Cretolamna** (AJ*), *Paraisurus* (AK), *Cantioscyllium* (AL), Scyliorhinidae (AM), *Dasyatis* (AN), *Microcorax* (AO), *Pararhindodon* (AP), *Ptychodus* (AQ), ?Dasyatidae (AR), *Squatirhina** (AS*), and *Cenocarcharias* (AT).

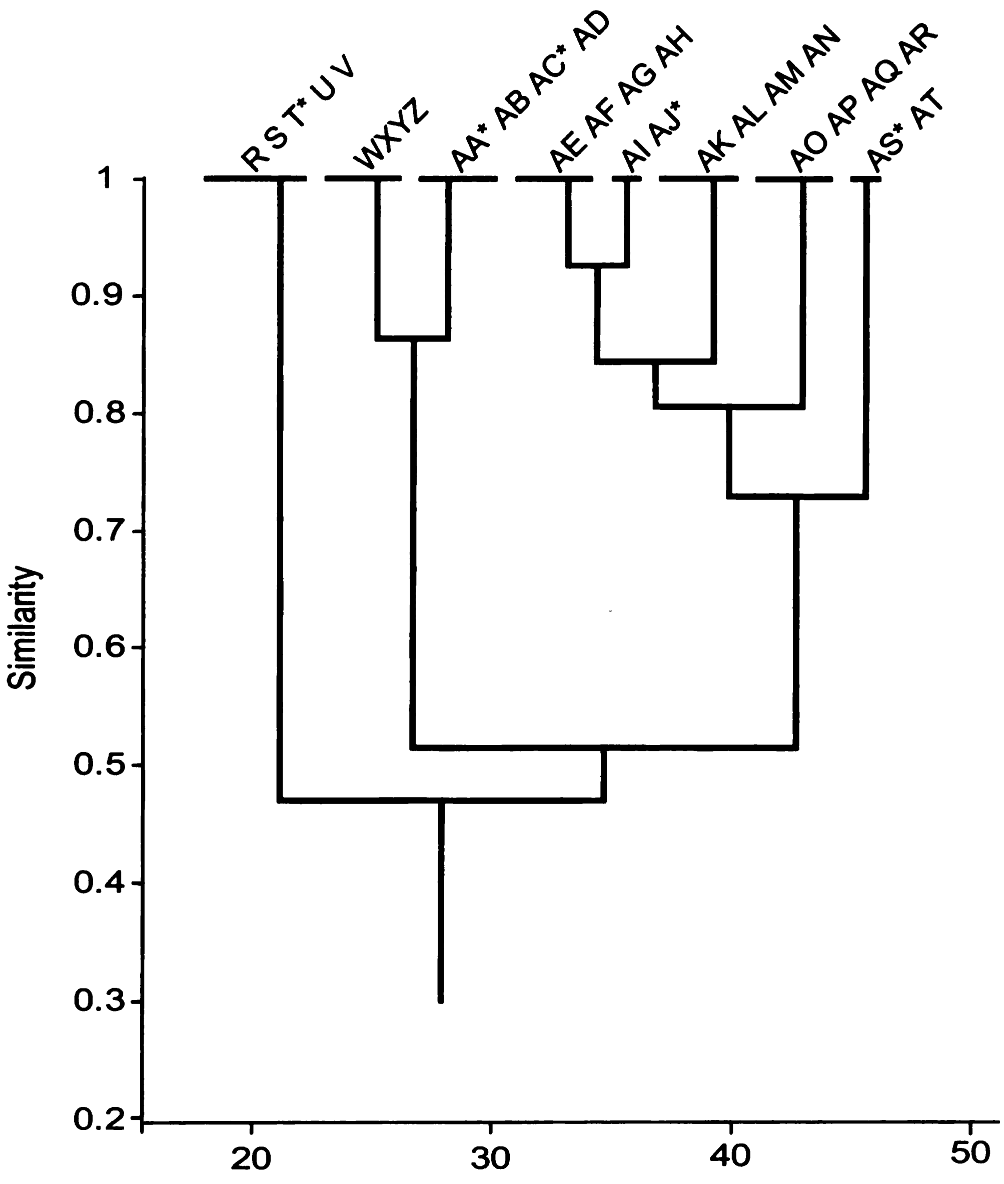

R S T* U V
WXYZ
AA* AB AC* AD
AE AF AG AH
AI AJ*
AK AL AM AN
AO AP AQ AR
AS* AT
Similarity
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
20
30
40
50

Figure 59. Subset from figure 56, bracket 3. Cluster analysis of genera by formation from the WIS. *Ginglymostoma* (AU), *Nebrius* (AV), *Anomotodon* (AW), *Scyliorhinus* (AX), *Squatigaleus* (AY), Triakidae or Carchiarhinidae indet. gen. (AZ), *Raja* (BA), *Hamrabatis* (BB), *Schizorhiza* (BC), *Coupatezia* (BD), *Texabatis* (BE), *Rhombodus* (BF), *Ewingia* (BG), *Protoplatyrhina** (BH*), *Peyeria* (BI), *Carcharias* (BJ), *Serratolamna* (BK), *Galeorhinus* (BL), *Chiloscyllium** (BM*), Somniosinae (subfamily) (BN), *Scapanorhynchus* sp. or *Carcharias* sp. (BO), *Onchosaurus* (BP), *Brachyrhizodus* (BQ), Myliobatidae (BR), *Texatrygon* (BS), *Heterodontus* (BT), *Pseudocorax* (BU), *Rhinobatos* (BV), *Sclerorhynchus* (BW), *Plicatoscyllium* (BX), *Squatina* (BY), *Squalus* (BZ), *Lissodus* (CA), *Hexanchus* (CB), Etmopterinae (subfamily) (CC), *Palaeogaleus* (CD), Rajidae (CE), and *Paranomotodon* (CF).

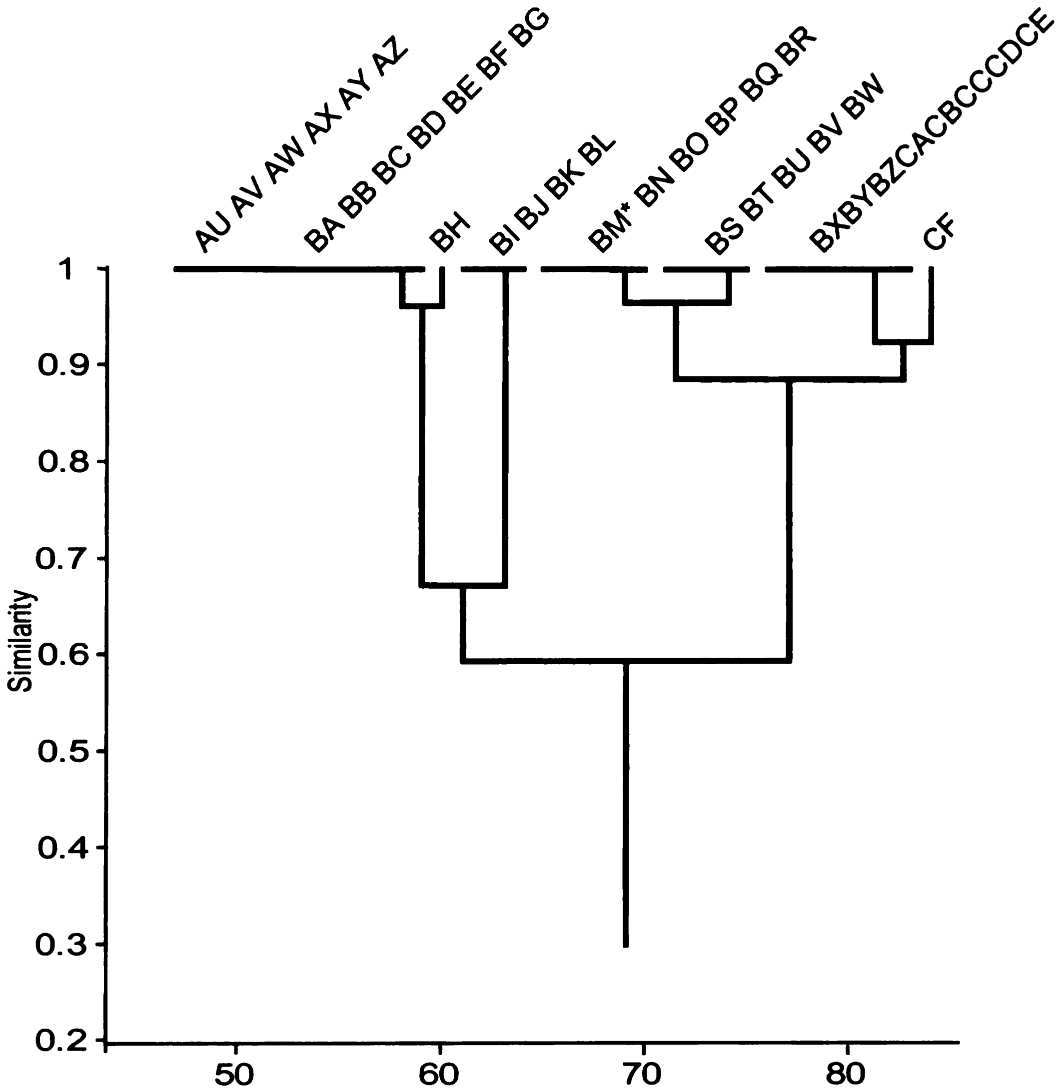
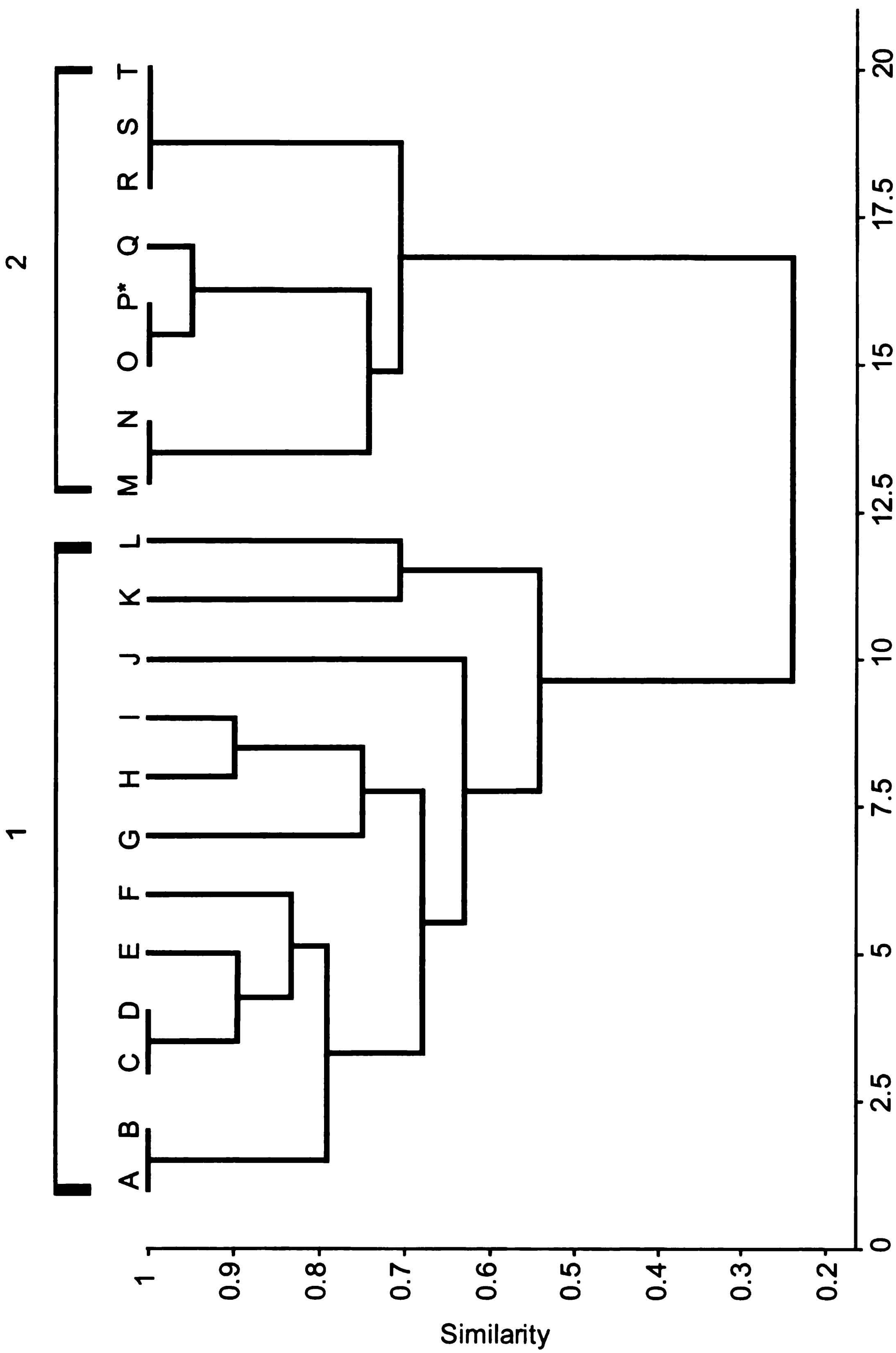

AU AV AW AX AY AZ
BA BB BC BD BE BF BG
BH
BI BJ BK BL
BM* BN BO BP BQ BR
BS BT BU BV BW
BXBYBZCACBCCCDCE
CF
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Similarity
50
60
70
80

Figure 60. Cluster analysis of formations by genera from the WIS.

Bracket 1
SD Carlile Shale (A), KS Carlile Shale Formation (B), KS Niobrara Chalk (C), TX Austin Group (D), TX Eagle Ford Group (E), AZ Greenhorn Cyclothem (F), KS Niobrara Formation (G), SD Greenhorn Formation (H), CO Greenhorn Limestone (I), TX Woodbine Group (J), TX Taylor Group (K), and TX Navarro Group (L).

Bracket 2
ND Hell Creek Formation (M), SK Judith River Formation (N), AB Judith River Formation (O), MT Judith River Formation* (P*), AB Dinosaur Park Formation (Q), WY Lance Formation (R), MT Hell Creek Formation (S), and WY "Mesaverde Formation" (T).



1
2
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P*
Q
R
S
T
0
2.5
5
7.5
10
12.5
15
17.5
20
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Similarity

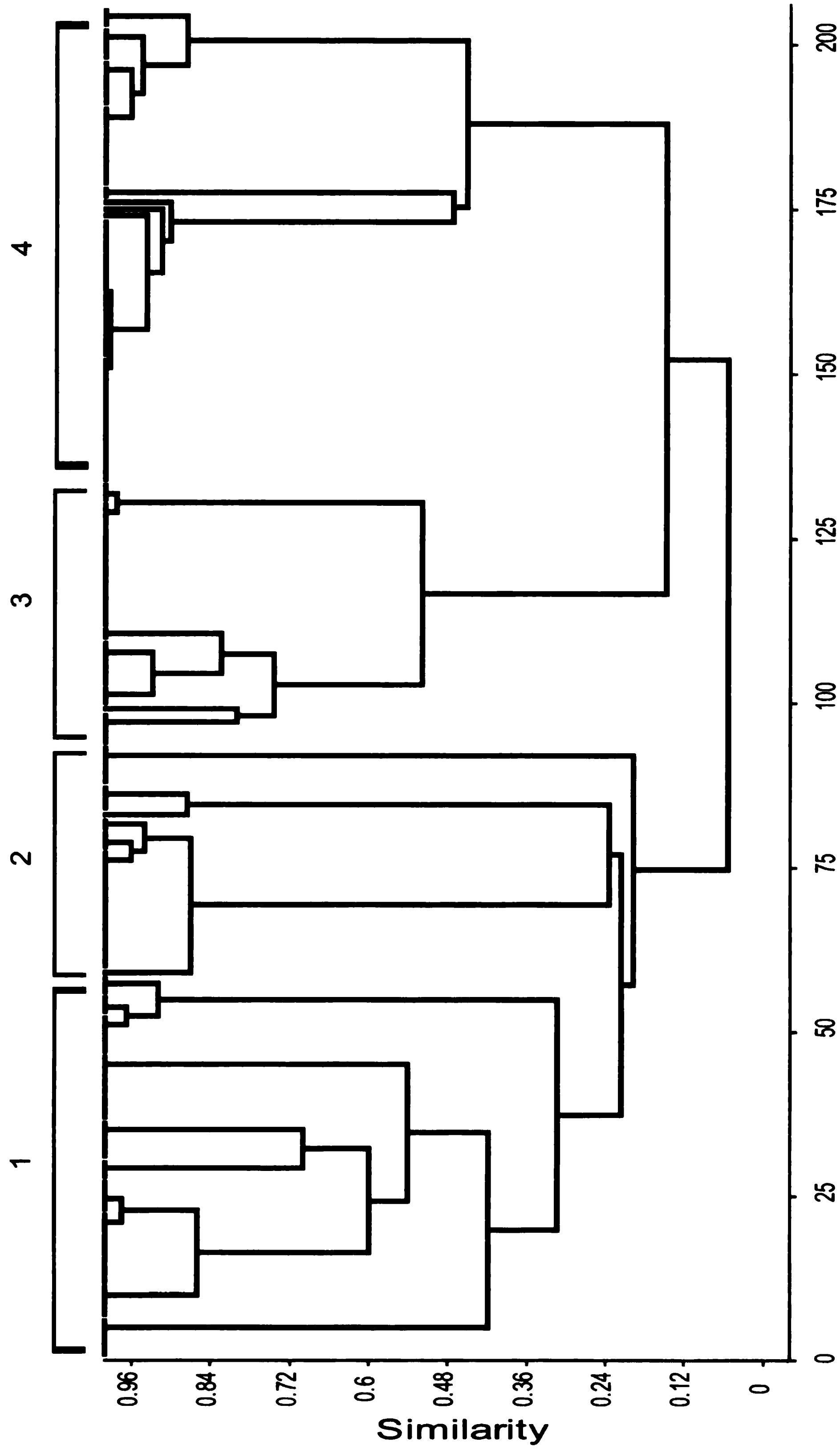


Figure 61. Cluster analysis of species by formation from the WIS. Each bracketed cluster is illustrated in more detail in Figures 62-65.

Figure 62. Subset from figure 61, bracket 1. Cluster analysis of species by formation from the WIS. *Odontaspis saskatchewanensis* (A), *Ptychodus rugosus* (B), *Synodontaspis lilliae* (C), *Cretodus* sp. (D), *Squalicorax falcatus* (E), *Cretomanta canadensis* (F), *Ptychodus whipplei* (G), *Ptychodus* sp. (H), *Ptychodus connellyi* (I), *Scapanorhynchus raphiodon* (J), *Rhinobatos incertus* (K), *Cretoxyrhina mantelli* (L), *Ptychodus mortoni* (M), *Protolamna compressidens* (N), *Squalicorax* sp. 1 (O), *Squalicorax* sp. 2 (P), *Rhinobatos kiestensis* (Q), *Rhinobatos lobatus* (R), *Kiestus texanus* (S), *Sclerorhynchus priscus* (T), *Sclerorhynchus* sp. (U), *Texatrygon hooveri* (V), *Dallasiella willistoni* (W), *Ptychodus latissimus* (X), *Hybodus* sp. 3 (Y), *Heterodontus* sp. (Z), *Chiloscyllium greeni* (AA), *Squalicorax volgensis* (AB), *Carcharias amonensis* (AC), *Squalicorax curvatus* (AD), *Ptychodus anonymus* (AE), *Polyacrodus illingsworthi* (AF), *Ptychodus occidentalis* (AG), ?Rhincodontidae (AH), *Carcharias* sp. A (AI), *Squalicorax* sp. (AJ), *Ptychodus mammilaris* (AK), *Ptychodus decurrens* (AL), *Chiloscyllium* sp. (AM), *Cretodus semiplicatus* (AN), *Cretolamna woodwardi* (AO), cf. *Leptostyrax* sp. (AP), *Protoplatyrhina hopii* (AQ), *Ischyrhiza schneideri* (AR), *Onchopristis dunklei* (AS), *Ptychotrygon rubyae* (AT), *Brachaelurus greeni* (AU), *Cantioscyllium decipiens* (AV), ?*Rhinobatos incertus* sp. (AW), ?Ganopristinae (AX), *Ptychotrygon ledouxi* (AY), *Ptychotrygon triangularis** (AZ*), *Rhinobatos* sp. (BA), *Synechodus illingworthi*? (BB), *Ptychodus polygyrus* (BC), *Johnlongia parvidens* (BD), *Synechodus* sp. (BE), and Family - ?Ganopristinae (BF).

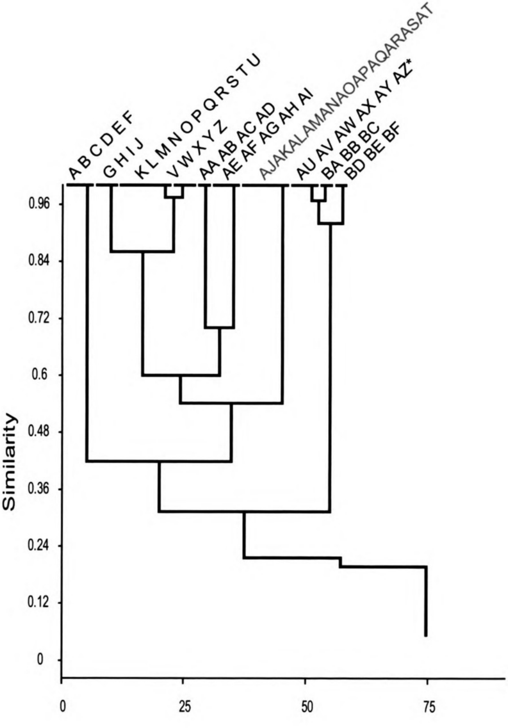

A B C D E F
G H I J
K L M N O P Q R S T U
V W X Y Z
AA AB AC AD
AE AF AG AH AI
AJAKALAMANAOAPAQARASAT
AU AV AW AX AY AZ*
BA BB BC
BD BE BF
0.96
0.84
0.72
0.6
0.48
0.36
0.24
0.12
0
Similarity
0
25
50
75

Figure 63. Subset from figure 61, bracket 2. Cluster analysis of species by formation from the WIS. ?*Pseudohypolophus* sp. (BG), *Odontaspis amonensis* (BH), *Lissodus* sp. (BI), *Hybodus* sp. (BJ), *Hybodus* sp. 1 (BK), *Hybodus* sp. 2 (BL), *Cretorectolobus* sp. (BM), *Pararhincodon* aff. *lehmani* (BN), *Cenocarcharias tenuiplicatus* (BO), *Odontaspis tenuiplicatus* (BP), *Scapanorhynchus* aff. *praeraphiodon* (BQ), *Leptostyrax macrorhiza* (BR), *Paraisurus compressus* (BS), *Protolamna carteri* (BT), *Squalicorax baharijensis* (BU), *Pseudohypolophus mcnultyi* (BV), *Ptychotrygon slaughteri* (BW), ?Dasyatidae (BX), *Enantiobatis tarrantensis* (BY), *Ptychotrygon hooveri** (BZ*), *Protolamna sokolovi** (CA*), *Cantioscyllium* sp. (CB), *Microcorax crassus* (CC), ?*Squatirhina* sp. (CD), *Ischyrhiza* sp.* (CE*), *Carcharias* sp. (CF), *Odontaspis* sp. (CG), *Cretolamna appendiculata** (CH*), *Peyeria* sp. (CI), cf. *Pararhincodon* sp. (CJ), *Carcharias saskatchewanensis* (CK), *Carcharias tenuiplicatus* (CL), cf. *Johnlongia* sp. (CM), Carcharhiniformes incertae sedis (CN), and *Ptychotrygon* sp. (CO).

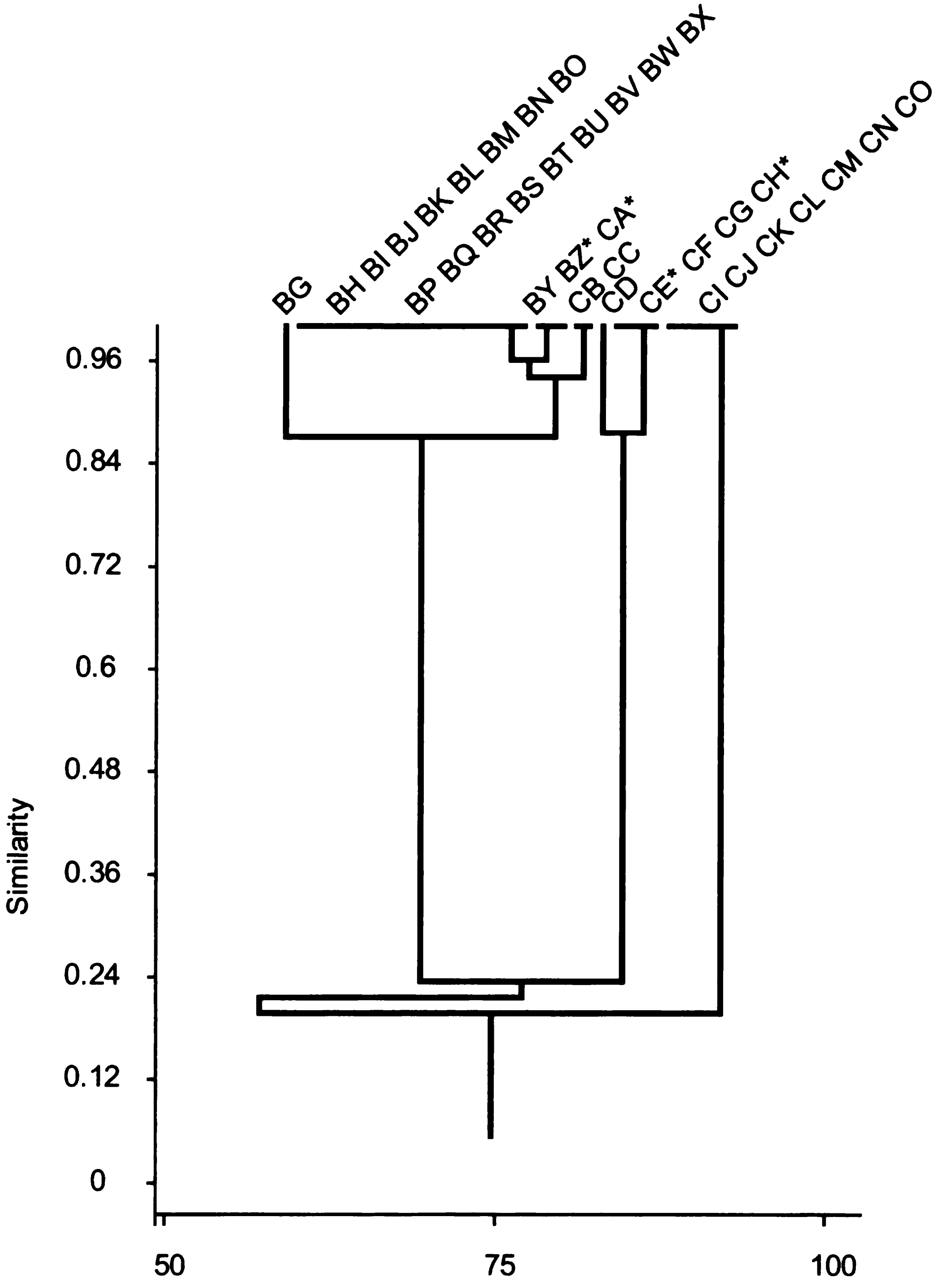

BG
BH BI BJ BK BL BM BN BO
BP BQ BR BS BT BU BV BW BX
BY BZ* CA*
CB CC
CD
CE* CF CG CH*
CI CJ CK CL CM CN CO
Similarity
0.96
0.84
0.72
0.6
0.48
0.36
0.24
0.12
0
50
75
100

Figure 64. Subset from figure 61, bracket 3. Cluster analysis of species by formation from the WIS. *Carcharias steineri* (CP), *Cretorectolobus olsoni** (CQ*), *Eucrossorhinus microcuspidatus** (CR*), *Protoplatyrhina renae** (CS*), *Ischyrhiza mira** (CT*), *Ptychotrygon blainensis** (CU*), *Squatirhina* sp.* (CV*), *Odontaspis sanguinei** (CW*), *Myledaphus bipartitus** (CX*), *Hypotodus* spp.* (CY*), *Synechodus andersoni** (CZ*), *Hybodus storeri** (DA*), *Hybodus montanensis** (DB*), *Synechodus striatus** DC*), *Hypotodus grandis** (DD*), *Archaeotriakis rochelleae** (DE*), Sclerorhynchidae indet.* (DF*), *Archaeolamna kopingensis** (DG*), *Brachaelurus bighornensis* (DH), *Lissodus griffisi* (DI), *Centrophoroides worlandensis* (DJ), *Synechodus turneri* (DK), *Chiloscyllium missouriensis** (DL*), *Ginglymostoma globidens* (DM), *Odontaspis cheathami* (DN), *Odontaspis steineri* (DO), *Pseudodontaspis herbsti* (DP), *Squalicorax kaupi** (DQ*), *Squalicorax pristodontus** (DR*), *Scyliorhinus tensleepensis* (DS), *Archaeotriakis ornatus* (DT), *Squatirhina roessingi* (DU), *Ankistrorhynchus washakiensis* (DV), *Ischyrhiza basinensis* (DW), *Ptychotrygon boothi* (DX), *Ptychotrygon ellae* (DY), *Ptychotrygon greybullensis* (DZ), *Rhinobatos casieri* (EA), and *Scapanorhynchus texanus* (EB).

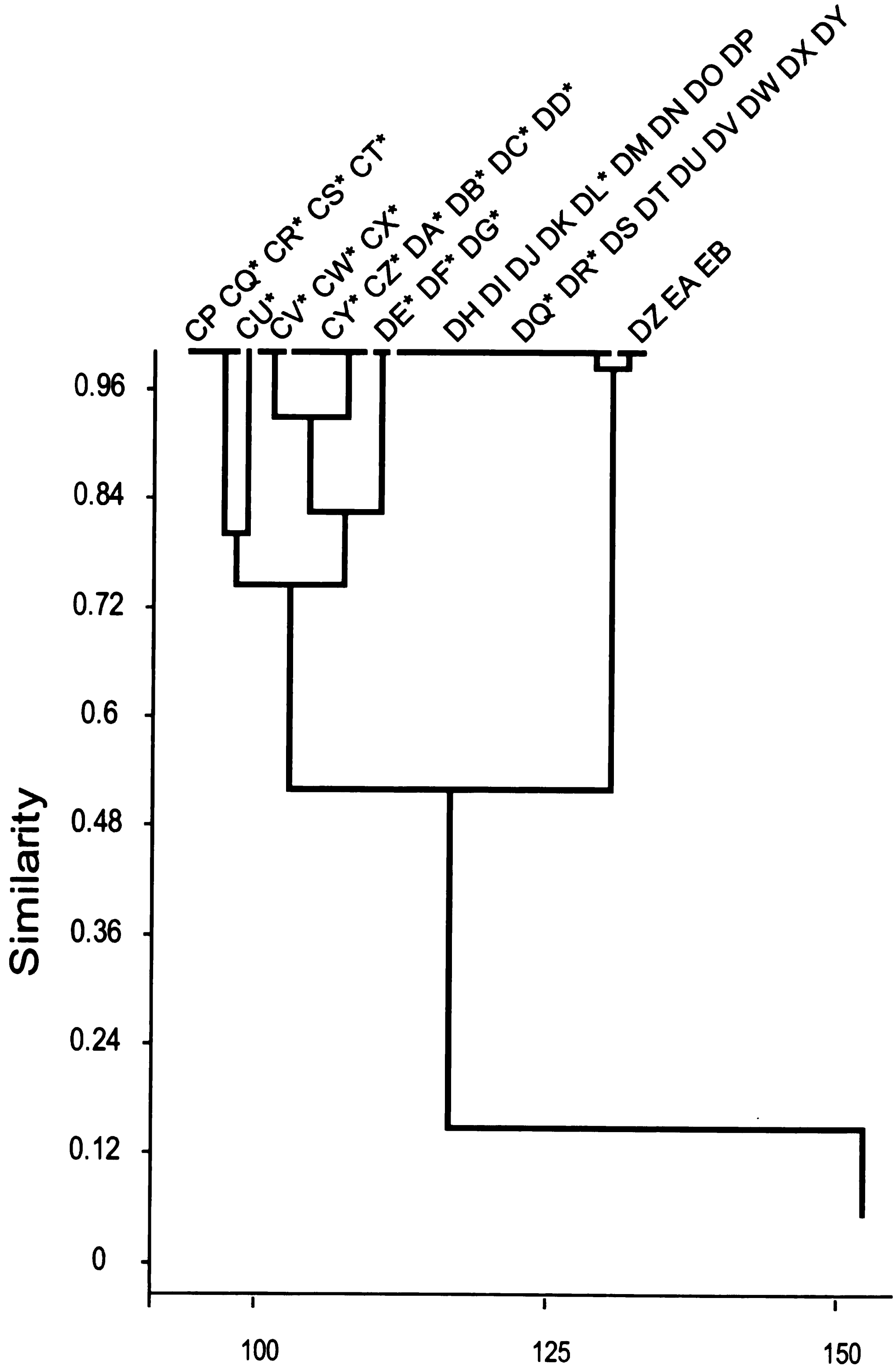

CP CQ* CR* CS* CT*
CU*
CV* CW* CX*
CY* CZ* DA* DB* DC* DD*
DE* DF* DG*
DH DI DJ DK DL* DM DN DO DP
DQ* DR* DS DT DU DV DW DX DY
DZ EA EB
Similarity
0.96
0.84
0.72
0.6
0.48
0.36
0.24
0.12
0
100
125
150

Figure 65. Subset from figure 61, bracket 4. Cluster analysis of species by formation from the WIS. *Hybodus wyomingensis* (EC), *Odontaspis aculeatus* (ED), *Hexanchus* sp. (EE), *Heterodontus granti* (EF), *Ginglymostoma* sp. (EG), *Nebrius* sp. (EH), *Rhinobatos craddocki* (EI), *Raja farishi* (EJ), *Hamrabatis weltoni* (EK), *Ischyrhiza monasterica* (EL), *Ptychotrygon vermiculata* (EM), *Ptychotrygon winni* (EN), *Schizorhiza* cf. *weileri* (EO), *Sclerorhynchus pettersi* (EP), *Coupatezia turneri* (EQ), *Dasyatis commercensis* (ER), *Texabatis corrugata* (ES), *Rhombodus binkhorsti* (ET), *Rhombodus*? sp. (EU), *Ewingia problematica* (EV), *Rhinobatos uvulatus* (EW), *Squalus* sp. (EX), *Lissodus* aff. *babulskii* (EY), *Lissodus* spp. (EZ), *Hexanchus microdon* (FA), *Squalus huntensis* (FB), *Squatina hassei* (FC), *Cantioscyllium meyeri* (FD), *Plicatoscyllium antiquum* (FE), *Carcharias heathi* (FF), *Carcharias holmdelensis* (FG), *Carcharias* cf. *samhammeri* (FH), *Carcharias* sp. 1 (FI), *Anomotodon toddi* (FJ), *Cretolamna maroccana* (FK), *Cretolamna* sp. (FL), *Scyliorhinus ivagrantae* (FM), *Galeorhinus* aff. *girardoti* (FN), *Palaeogaleus navarroensis* (FO), *Squatigaleus sulphurensis* (FP), Triakidae or Carcharhinidae indet. gen. (FQ)$^+$, *Scyliorhinus arlingtonensis* (FR) $^+$, *Ptychotrygon texana* (FS) $^+$, *Scapanorhynchus* sp. (FT), *Squatirhina americana* (FU), *Ischyrhiza avonicola** (FV*), *Rhinobatos ladoniaensis* (FW), *Lissodus selachos* (FX), Somniosinae (subfamily) (FY), Etmopterinae (subfamily) (FZ), *Pararhincodon groessenssi* (GA), *Scapanorhynchus* sp. or *Carcharias* sp. (GB), *Scyliorhinus taylorensis* (GC), *Onchosaurus pharo* (GD), *Sclerorhynchus fanninensis* (GE), *Sclerorhynchus* sp. (GF), *Texatrygon copei* (GG), Myliobatidae (GH), *Ptychotrygon aguja* GI), *Plicatoscyllium derameei* (GJ), *Carcharias* sp. B (GK), *Serratolamna serrata* (GL), *Galeorhinus* sp. (GM), *Palaeogaleus* sp. (GN), Rajidae (GO), *Brachyrhizodus wichitaensis* (GP), *Pseudocorax granti* (GQ), Scyliorhinidae (GR), *Ischyrhiza texana* (GS), *Dasyatis* spp. (GT), *Sclerorhynchus* sp. (GU), *Heterodontus* cf. *canaliculatus* (GV), and *Paranomotodon* sp. (GW).

Note: Triakidae or Carcharhinidae indet. gen. (FQ)$^+$, *Scyliorhinus arlingtonensis* (FR) $^+$, *Ptychotrygon texana* (FS) $^+$ are offset in the figure due to crowding of the tree.

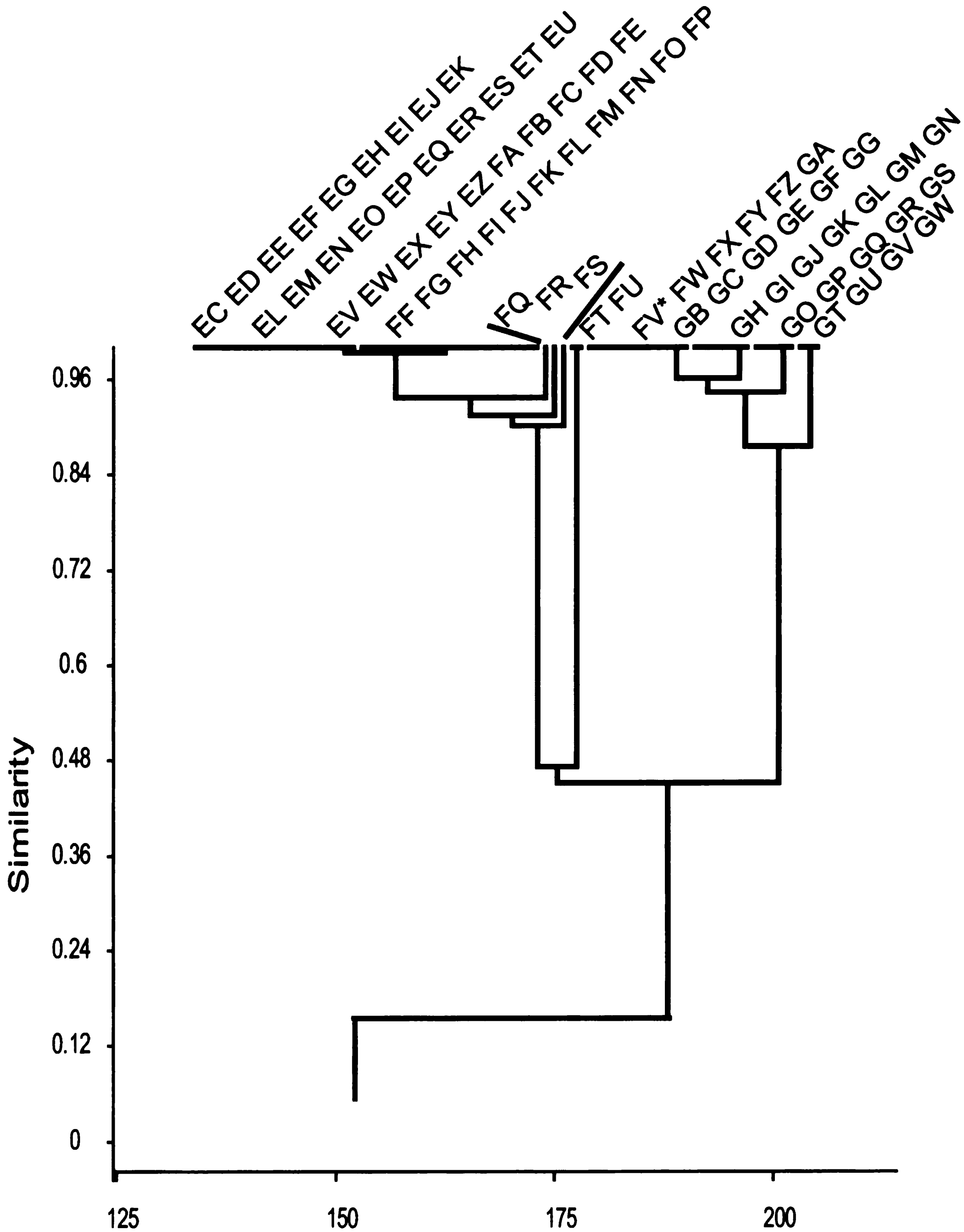
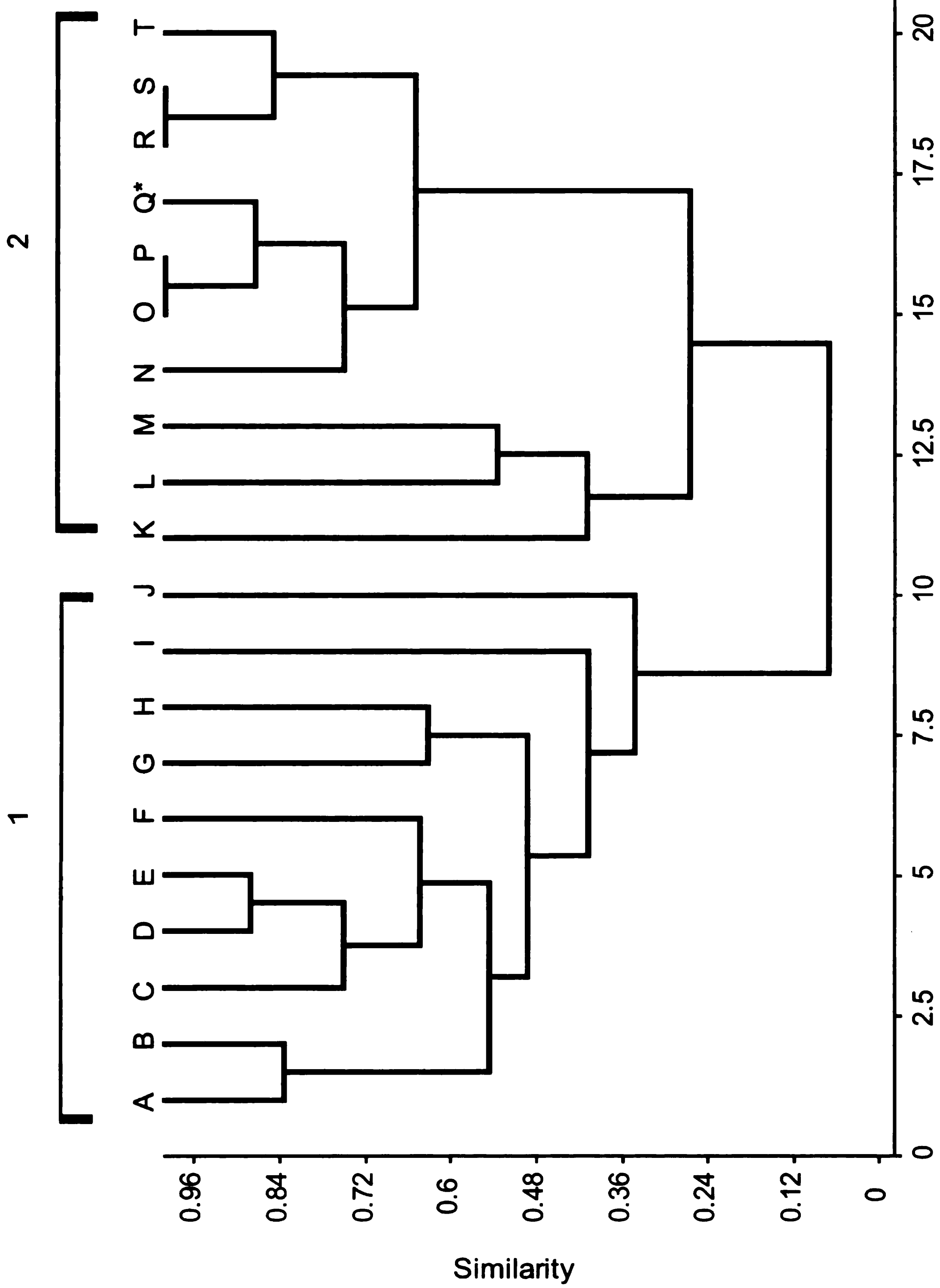

EC ED EE EF EG EH EI EJ EK
EL EM EN EO EP EQ ER ES ET EU
EV EW EX EY EZ FA FB FC FD FE
FF FG FH FI FJ FK FL FM FN FO FP
FQ FR FS
FT FU
FV* FW FX FY FZ GA
GB GC GD GE GF GG
GH GI GJ GK GL GM GN
GO GP GQ GR GS
GT GU GV GW
Similarity
0.96
0.84
0.72
0.6
0.48
0.36
0.24
0.12
0
125
150
175
200

Figure 66. Cluster analysis of formations by species from the WIS.

Bracket 1
SD Carlile Shale (A), KS Carlile Shale Formation (B), KS Niobrara Chalk (C), TX Eagle Ford Group (D),TX Austin Group (E), AZ Greenhorn Cyclothem (F), SD Greenhorn Formation (G), CO Greenhorn Limestone (H), KS Niobrara Formation (I), and TX Woodbine Group (J).

Bracket 2
ND Hell Creek Formation (K), TX Taylor Group (L), TX Navarro Group (M), WY Lance Formation (N), MT Hell Creek Formation (O), SK Judith River Formation (P), MT Judith River Formation* (Q*), WY "Mesaverde Formation" (R), AB Judith River Formation (S), and AB Dinosaur Park Formation (T).


1
2
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q*
R
S
T
0
2.5
5
7.5
10
12.5
15
17.5
20
0.96
0.84
0.72
0.6
0.48
0.36
0.24
0.12
0
Similarity

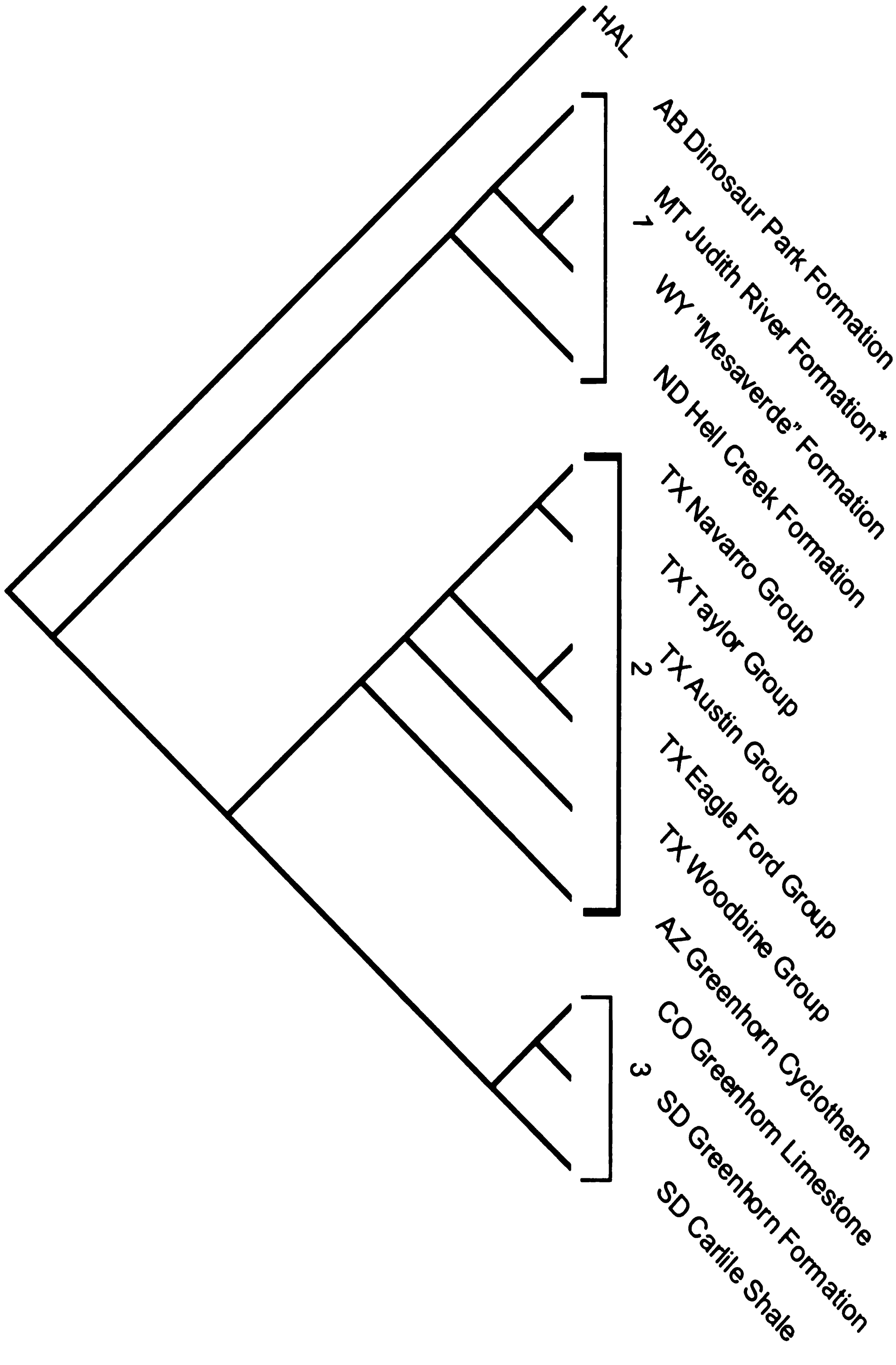


Figure 67. PAE strict consensus of WIS genera.

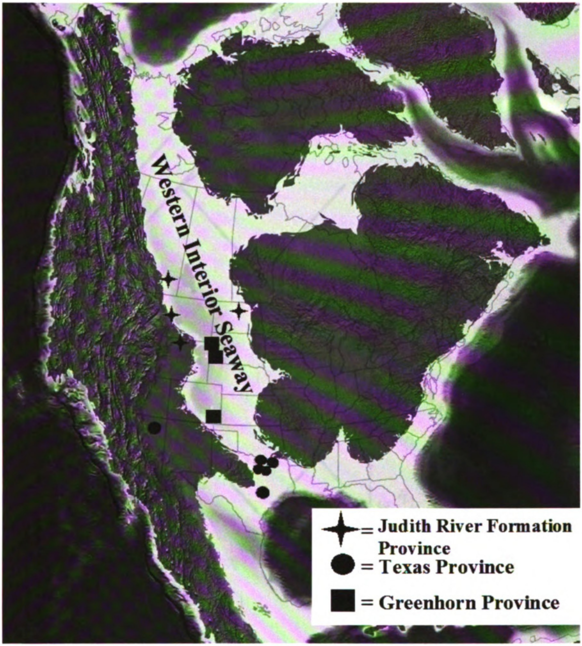


Figure 68. Western Interior Seaway (WIS) 75 Ma (approximate age of the JRF in Montana) - geographical focus for JRF faunal comparisons with local areas/formations of this study roughly positioned, provinces by genera (modified from Blakey, 2009).

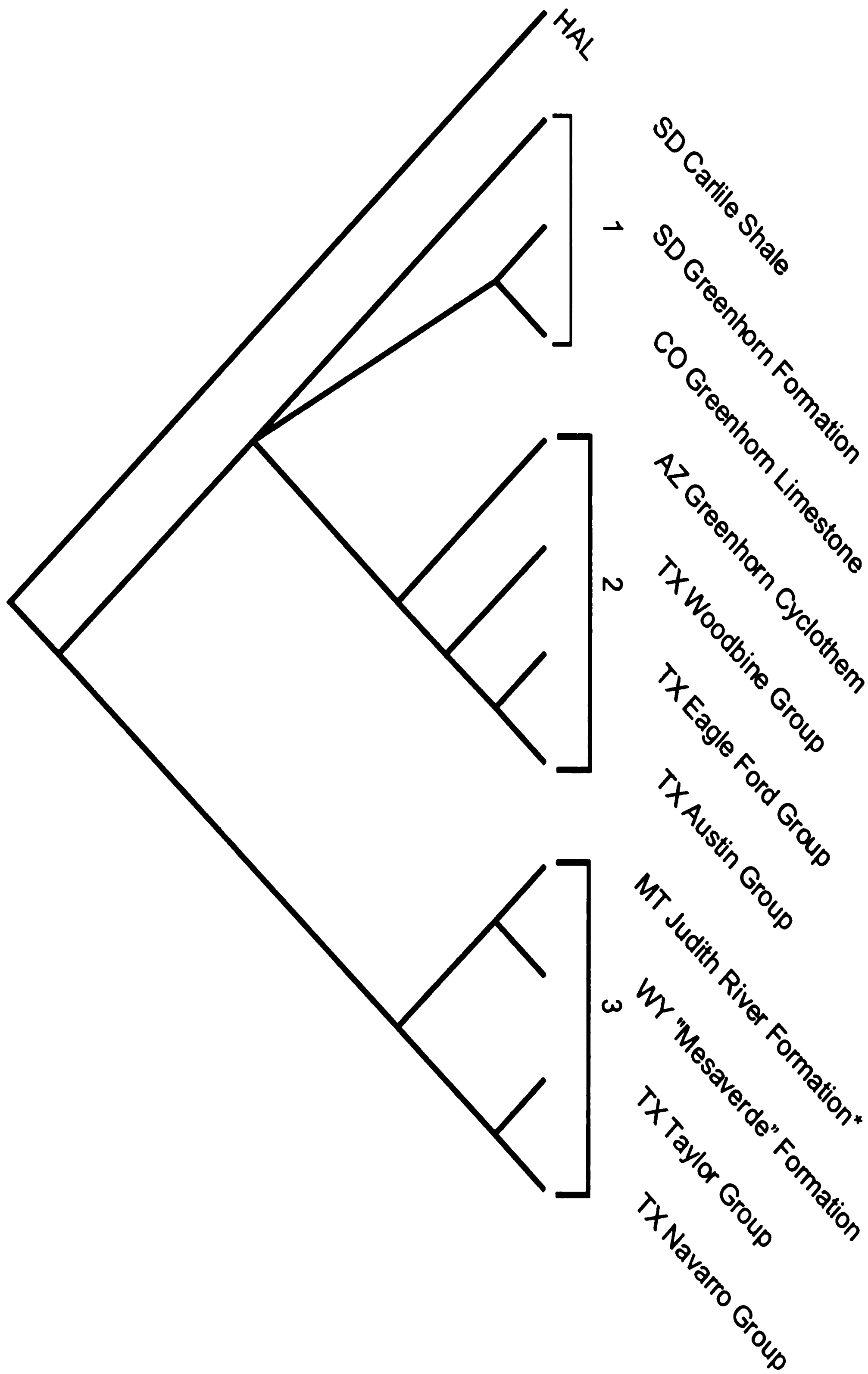


Figure 69. PAE strict consensus of WIS species.

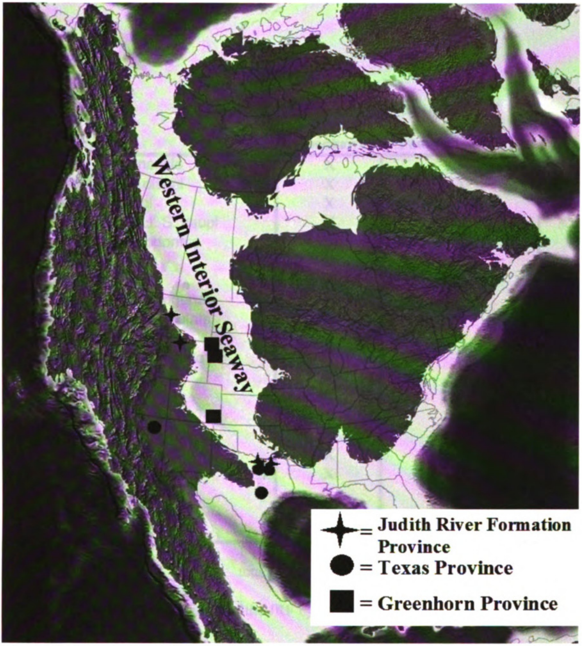


Figure 70. Western Interior Seaway (WIS) 75 Ma (approximate age of the JRF in Montana) - geographical focus for JRF faunal comparisons with local areas/formations of this study roughly positioned, provinces by species (modified from Blakey, 2009).

	Woodhawk	Power Plant Ferry
Hybodus montanensis	X	
Cretorectolobus olsoni	X	X
Squalicorax kaupi	X	X
Squalicorax sp., cf. S. kaupi	X	X
Squalicorax pristodontus		X
Hypotodus grandis	X	X
Hypotodus spp.	X	X
Archaeolamna kopingensis	X	X
Cretolamna appendiculata	X	X
Protolamna sokolovi	X	X
Archaeotriakis rochelleae		X
Protoplatyrhina renae	X	X
Squatirhina sp.	X	
Ischyrhiza avonicola	X	
Ischyrhiza mira	X	X
Ptychotrygon hooveri	X	X
Ptychotrygon triangularis	X	X
Sclerorhynchidae indet.	X	X
Myledaphus bipartitus	X	X
Ischyodus	X	
totals	18	16

Table 9. Chondrichthyan fauna of the JRF by bonebeds.

CHAPTER FOUR

TAPHONOMY

While taphonomy is a growing field within paleontology, little work has been done in the area of marine vertebrate paleontology. The observed preservational states of chondrichthyan teeth from the Woodhawk Bonebed (WH) and later from the Power Point Ferry Bonedbed (PPF) prompted an actualistic experiment on extant shark and ray teeth in an attempt to simulate post-mortem/post-shedding transport and develop a taphonomic scale.

Background

Taphonomy, which has its origins in bioerosion studies in the 1800s (Tryon, 1863; Wright, 1866; and Whitfield, 1893 among others), has been largely ignored until relatively recently (Behrensmeyer, 1991; Lyman, 1994; and Rogers and Kidwell, 2000). It is now a fast growing discipline within paleontology. Taphonomy is the study of the processes and conditions that affect how organisms become fossilized. As defined by Efremov (1940: 85) it is "the study of the transition (in all its details) of animal remains from the biosphere into the lithosphere." Any taphonomic terms and definitions used here will follow Behrensmeyer (1991) and Lyman (1994). Much of the taphonomic literature is not directly applicable to the current study as it concentrates on invertebrates or terrestrial vertebrates. One exception is the work of Weigelt (1989). The bulk of his observations were on terrestrial vertebrates, both extant and fossil, but he did investigate stranded extant fishes on a Texas lakeshore as well as the fossil fishes of the Eocene

(Messel) and Miocene of Europe. Experimental work on shark teeth (Tulu, 2006 and 2007 and Irmis and Elliott, 2006) and marine mammals (Van Orden and Godfrey, 2008) are among the more recent studies that have looked at taphonomy of marine vertebrates.

Previous work on JRF taphonomy

Rogers, Rogers and Eberth, and Rogers and Kidwell

A study by Rogers (1998) on the JRF and the Two Medicine Formation showed that the sequence analysis of the regressions and transgressions during the Late Cretaceous could be used for the evaluation of terrestrial taphonomy in the context of sea-level cyclicity. In their study on the JRF in Montana and the Oldman Formation and Dinosaur Park Formation in southern Alberta, Rogers and Eberth (1996) discovered that there is a taphonomic signal; the increase in relative abundance of vertebrate microfossil assemblages correlate with the lower coastal plain environment, and suggests that the microfossil vertebrate assemblages can be used in basin analysis. Rogers and Kidwell (2000) suggests that vertebrate skeletal accumulation is not a reliable proxy to locate stratigraphically significant layers because the appearance of skeletal accumulations is not predictable. It also demonstrated that the distribution of fossils on erosionally controlled hiatal surfaces may be unrelated to the hiatus, and that, in fact, the discontinuity surfaces (where the bonebeds occur) associated with the vertebrate skeletal concentrations are time-averaged mixtures of ecologically and/or taphonomically disparate fossil material.

LaRock et al.

LaRock et al. (2000a-b) discovered a rich concentration of hadrosaur dinosaur bones in northeastern Montana. The bones were preserved in an estuarine deposit and showed minimal weathering, some scavenging, and no winnowing of the bones. The well preserved nature of the bones suggests that the bodies of the dead hadrosaurs stayed intact through transport until encountering an obstacle (a tree in this instance) whereupon they backed up creating a "logjam."

These recent field studies described terrestrial and marine taphonomy of vertebrate and invertebrate fossils of the JRF. However none of the studies focused on elasmobranch teeth, though they are mentioned as being present in the lag deposits in association with marine reptile bones and terrestrial teeth (mammal and dinosaur) (Rogers and Kidwell, 2000).

New observations and questions on JRF taphonomy

Initial observations of the preservational states of the teeth and associated fossils from the Woodhawk Bonebed (WH) fauna led to questions regarding the taphonomy of fossils found in the bonebed. These questions also became key to the original thrust of this project, which was a study of the fauna and the paleoenvironment. For example, taphonomy can add to the challenges of identifying the shark teeth leading to misidentification. Taxonomic studies by Siverson (1995) and Naylor and Marcus (1994) did not factor in taphonomy. Misidentification due to taphonomic factors should not be an issue with the material presented here as any tooth lacking diagnostic features was left unidentified. Preservation of fossil teeth in the WH fossils ranges from pristine or what was later deemed near pristine teeth (which accounts for ~38% of the WH material), along with dermal denticles, preserved bits of prismatic cartilage, and fragmentary teeth, centra, and extremely friable chimaerid tooth plates. The mixed quality of preservation suggests influences by a range of taphonomic processes prior to final burial (Tulu, 2007).

Taphonomic features of *Archaeolamna kopingensis* teeth

Striations

Archaeolamna kopingensis teeth from the WH were chosen for an initial taphonomic analysis because of their abundance, what seemed to be the full range of preservational states from pristine to broken, and they were of sufficiently large size to be used for this study. As noted earlier in the systematic paleontology section, some of the *A. kopingensis* teeth bear striation patterns of white or gray set against a brown or darker gray background. The white striations are presumed to be remnant original tooth enamel. The white remnants, if they are enamel, present in these striate patterns pose questions regarding the enamel and how it is retained, lost, or perhaps altered diagenetically.

It has been proposed and assumed that the striations such as those seen in other fossils were caused by plant roots, however there had been no documentation to support this until a preliminary experimental study by Zook and Behrensmeyer (2008), who utilized modern bone with encouraging results. After two months of burial beneath snow peas, the surface of bovid bone showed degradation and the outermost cortical bone stripped away. SEM images showed a shallow root trace network. Underwood et al. (1999) also investigated potential root action on fossils, however the markings actually proved to be post-mortem microborings by colonization of endolithic organisms such as *Mycelites* and *Abeliella*. Based on these studies, striations appear to be a post-depositional features related to post-burial biotic activity. A related question can investigate whether extant and fossil material is affected in the same manner in root experiments (and endolithic organisms).

Rounding/breakage

In addition to the striations, all of the *Archaeolamna kopingensis* teeth display some degree of rounding of the cusps, cutting edges, and/or root. Gross morphological features such as the cusp, cusplets, and root lobes are on the whole preserved. Teeth that show any breakage typically show one side of the lateral cusplet(s) broken off, breakage that in most cases appear to be fresh as there is no rounding of the fractured end and the surface is clean of sediment dust. Approximately 27% of all teeth are broken (Table 10). Tooth breakage tends to occur through the root between the main cusp and the lateral cusplet(s), related to potential weak points in the teeth. The initial collection from the WH contains ~8.5% (Table 23) of broken cusps, broken roots, and many cusps that were not identifiable other than being some sort of lamniform (Figure 71).

Preliminary Taphonomic Characterization Scale for *Archaeolamna kopingensis* teeth

Variable *Archaeolamna kopingensis* tooth preservation led to a preliminary taphonomy scale (Table 10) comprising these categories:

- "Pristine with patchy coloration,"

- "Root minimally abraded with patchy crown coloration,"
- "Pristine with crown tip broken,"
- "Root abraded with patchy coloration,"
- "Broken," and
- "Broken with patchy coloration."

Teeth are listed by their approximate position within the mouth, anterior, lateral, and posterior. The placement of teeth by position should be regarded as approximate. "Pristine" teeth are represented in all tooth positions with 37.5% of all teeth being pristine (Table 10). The "Broken patchy coloration" teeth are also represented in all tooth positions with 18.8% of the total teeth (Table 10). The remaining categories are not present in all tooth positions but they comprise 43.8% of all teeth (Table 10). There appears to be no special trend or distribution of teeth over position and preserved state, however a X^2-test was employed to test the null hypothesis that tooth preservation is independent of tooth position.

X^2-test of Preliminary Characterization Scale (Observed versus Expected)

The X^2-test is used to measure how far the observed counts (teeth per category) are from the expected counts (Moore, 2000). To employ the X^2-test for the data in Table 10, expected values were calculated (Siegel, 1956) in Table 11 where "o" = observed and "e" = expected values. Data were also analyzed with the program PAST. Excel and PAST calculated the X^2 where $p = 0.31861$ (for anterior), 0.1245 (for lateral), and 0.27954 (for posterior) (full PAST readout is available in Appendix E). Using the standard p = 0.05 none of the calculated values are significant at that level. It would appear that the distribution of teeth is within normal parameters and therefore the null hypothesis is accepted. One factor that needs to be taken into account is the problem of insufficient data,

> The chi-square test is not accurate if any of the cells contain fewer than five items (as a rule if thumb). (Hammer and Harper, 2006: 58)

This is also supported by Siegel (1956: 110). As 11 of the 18 cells have fewer than five teeth (with six cells that have zero teeth), this test may not be an appropriate assessment of the data. The data are categorical in nature, which is what the X^2-test is used for, however the sample size is just barely large enough with 40 being the minimum for a sample size (Siegel, 1956: 110). One solution would be to increase the sample size but that is not always possible, particularly with fossil data. This is especially the case when one of the sites from which the fossils originate (WH) no longer exists. With the addition of teeth screen washed by RRR and a final tally of teeth from both the WH and PPF sites, additional X^2-tests were employed, again testing the null hypothesis that tooth preservation is independent of tooth position (below).

Addendum

A further examination of the *Archaeolamna kopingensis* teeth, in conjunction with the WH material screenwashed by RRR on site and *Archaeolamna kopingensis* teeth from the Power Plant Ferry Bonebed (PPF) (Figure 72), suggested a revision to the initial taphonomic characteristic scheme in Table 10. Additional categories were created and some previous categories were combined with others (Tables 12a-b). For example, one new category is "Pristine" which means the tooth is pristine in every respect except in color (it will be uniform but not necessarily the original color of the tooth). Consequently the category previously listed as "Pristine with patchy coloration" is now "Almost pristine may have patchy coloration." The new category of "Pristine" means that a tooth is sharp to the touch while the new "Almost pristine may have patchy coloration" category with slightly dulled edges. A new category of "Cusplets" was erected for the WH group (Table 12a) and a category of "Pristine but cusp or root only" for the PPF group (Table 12b), however upon statistical consult (Ma, personal communication) from the Center for Statistical Training and Consulting (CSTAT) the last two categories were not utilized in statistical tests of the site-by-site comparison.

The revised *Archaeolamna kopingensis* total for WH is 77 teeth (or pieces of teeth in the form of cusplets) (Table 12a) and the PPF has a total of 45 teeth (or pieces of teeth) (Table 12b). There are no pristine teeth from the WH, but the "Almost pristine may have patchy coloration" category has the most teeth (37.7% of the total) followed by 27.3% in the "Broken may have patchy coloration" category (Table 12a). The remaining 35.1% covers the rest of the categories that are not represented in all tooth positions. Nearly 50% (49.4%) of the total teeth are posteriors, followed by anteriors (28.6%), and lastly the laterals (22.1%) (Table 12a). Assigned tooth positions are tentative, particularly with the ambiguous transitional teeth.

Pristine teeth from the PPF comprise 17.8% of the total teeth but the "Broken may have patchy coloration" category has the most teeth (60% of the total) with the remaining 22.2% covering the remaining categories, which again are not represented in all of the tooth positions (Table 12b). Lateral teeth are the largest component of PPF with 44.4% of the total teeth followed by the anteriors (42.2%) and lastly the posteriors (13.3%). As there appeared to be no special trend or distribution of teeth over position and preserved state the X^2-test was again employed in order to determine if there is any significance in the distribution of teeth. The X^2-test is employed for both the WH and PPF data sets to test the null hypothesis that tooth preservation is independent of tooth position for each site.

X^2-test of Preliminary Taphonomic Characterization (Observed versus Expected)

Following the steps above for the X^2-test, the expected values for the WH are presented in Table 13a. The category of "Cusplets" was omitted as teeth were of indeterminate position so the sample size was actually 63. Excel and PAST calculated the X^2 where $p = 0.22893$ (for anterior), 0.49844 (for lateral), and 0.76164 (for posterior) (full PAST readout is available in Appendix E). It would appear that the distribution of teeth is within normal parameters and the null hypothesis is accepted. In this test 12 of the 19 cells have values less than five (with six cells that have zero teeth), so despite the addition of the screened material, there are still not sufficient data for this test.

The expected values for the PPF are presented in Table 13b. Excel and PAST calculated the X^2 where $p = 0.75703$ (for anterior), 0.39585 (for lateral), and 0.55207 (for posterior) (full PAST readout is available in Appendix E). The distribution of teeth is within normal parameters, so the null hypothesis is accepted. In this test 18 of the 21 cells have values less than five (with eight cells that have zero teeth). As per the previous tests, the quantity of data for PPF indicates that there are insufficient data to make this test meaningful.

These X^2-tests imply that the null hypothesis is accepted for all of the tests, and that tooth preservation is independent of tooth position albeit unconvincingly given the small sample sizes. Both sites have normal distributions of teeth over different states of preservation. This also implies that any initial differences in observations made of the teeth from each site is insignificant. However, Hammer and Harper (2006) state that cell values less than five will produce an inaccurate analysis. Sixty-eight percent of the cells in the WH data set and ~89% of the cells in the PPF data set are below the minimum value and PPF also has a relatively small sample size of 45 teeth, not much larger than the minimum (40) needed for this test. To remedy this more material must be collected to further refine the categories and raise overall cell values. However, as the WH site ceases to exist the data set presented here is all that is available for testing.

X^2-test of WH versus PPF

The PAST program is able to test the categorical data in a site-by-site comparison, as such, tested here is the null hypothesis that there is no difference between the WH and PPF sites in terms of preservation. The raw data for both sites is repeated in Tables 14a-b with the X^2-test results from PAST where $p = 1.5411E\text{-}06$ (for total teeth comparison), 0.0059169 (for anterior), 0.0021158 (for lateral), and 0.0036427 (for posterior) (full PAST readout is available in Appendix F). This analysis did not include the categories of "Cusplets" as they are not separated out by position. Additionally upon consult from CSTAT (Ma, Ma, personal communication), the "Cusplets" and "Pristine but cusp or root only" categories were not used as they were not categories in both sites. This reduces the total sample size to 63 teeth for WH and 42 teeth for PPF. The very low p values indicate that they are very significant ($p < 0.005$). This corroborates initial observations that there is a difference in preservation between the WH and PPF sites and that the null hypothesis is rejected. However as previously mentioned, Siegel (1956) and Hammer and Harper (2006), state that cells with values of five or less make an analysis less accurate. Over Tables 14a-b, 13 of 36 cells with zero values and an additional 16 cells with values of five or less, leaving only seven cells with values higher than five. That is ~81% of the cells that would be considered "unusable" as the addition of small values increases the rate of error in the X^2 analysis. Even using only the total values there are seven of 12 cells with values of five or less, or ~58% of the cells that are "unusable." This, coupled with the smaller data set, makes the tests less reliable.

Batoids

The batoid teeth collected for this study show little variation in their preservation. The teeth of *Protoplatyrhina renae* were either pristine (Figure 43 and 44) or lack roots. Teeth without roots may occur because elasmobranch roots are not covered with an enamel layer as is the crown, making them more susceptible to wear. This did not hamper identification as these teeth retained all other features (small size, smooth and thick crown that is hexagonal to rhombodic or circular to oval in occlusal view) for systematic diagnosis. Morphologically batoid teeth are very different from the lamnoid teeth. Lamnoid teeth have projections – cusps and root lobes that are more susceptible to damage either pre-shedding/pre-mortem or post-shedding/postmortem. Batoid teeth are compact, more globular, have shallow roots, and lack projecting morphological features that would be susceptible to damage.

Chimaerids

Chimaerid tooth plate fragments in this study cannot be identified to a particular taxon. Approximately 50% of the chimaerid pieces collapsed when they were handled, reflecting an altered and weaker structure. The chimaerid tooth plates may be extra delicate as they are structured differently from the teeth of the sharks, skates, and rays. The plates are composed of a meshed system of trabecular dentine that contains interspersed odontoblast ball chains and vascular channels, and it may be that this meshed system is not as structurally sound as the "normal" structure of shark teeth (Peyer, 1968). Because of the poor preservation of the chimaerid tooth plates, this makes them less conducive for further study without complete destruction of the material and therefore they do not figure in the taphonomic discussion.

Cartilaginous elements

Also not figuring in the taphonomic discussion are cartilaginous elements such as centra and prismatic cartilage that were also recovered from the matrix. Cartilage does not preserve readily in the fossil record as it "...has a lower structural density than bone" (Lyman, 1994: 79) unless it is calcified (Welton and Farish, 1993).

Experimental tooth taphonomy

Previous work

Argast et al.

Argast et al. (1987) experimented on a limited sample size (5 fossil reptilian teeth consisting of four tyrannosaurids and one crocodilian) to determine the effects of transport on tooth morphology. Utilizing a simple tumbler in a laboratory setting, Argast et al. (1987) showed that the teeth, after being tumbled for a distance equivalent to 360-380 kilometers, based on the barrel dimensions, rpm, and duration of the experiment, displayed so little change that, had they not been investigated prior to tumbling, the differences would not have been noticed. Some initial breaking of the roots occurred, but there was no rounding of the roots, cusps, or the broken portions of the roots. Overall tooth shape was retained, and surfaces were smoothed and polished with some transport-induced scratches on one tooth. Serrations present on tyrannosaurid teeth also retained their shape. Argast et al. (1987) concluded that it was not possible to detect limited effects of transport on reptilian teeth, and therefore differentiating reworked reptilian teeth from non-reworked material was not feasible.

Ely and Rigby and Ely

As a response to the limited scope of the Argast et al. (1987) study, Ely and Rigby (1989) and Ely (1995) ran similar experiments in a race-track flume using modern archosaur (alligator and crocodile) teeth. With a sample size of ten teeth Ely and Rigby (1989) determined that transport induced abrasion on their specimens was indeed produced. Ely (1995) showed abrasion features after only 2 hours of transport (unknown sample size), and determined that if teeth were to be preserved in an unmodified condition, the teeth would have to be buried rapidly with little to no transport and little to no reworking. Their findings implied that conclusions arrived at by Argast et al. were premature.

Irmis and Elliott

Another study (Irmis and Elliott, 2006) utilized a total of 9 modern shark teeth in a reciprocal shaker with salt water and sediment (analogous to the environment they were trying to simulate) to simulate wave action of a nearshore environment. The project was run for 1000 hours and their results showed progressive degradation of specimens with time. These authors looked at change in mass and the physical changes of the tip of the cusp, the tips of the root lobes, and the area of the lingual groove.

Present study

<u>Experimental taphonomy of shark teeth</u>

The present study uses a larger sample size of teeth, a greater frequency of measurements, measurements of several dimensions, and multiple measurements (replicates) of each dimension over previous studies. This study offers more statistically robust results to quantify tooth modification through abrasion due to transport. The experiment will test the null hypothesis that there is no change in preservation with time in a dynamic environment. While it is obvious that there will be change, this is tested to demonstrate as such both qualitatively and quantitatively.

Methods

Instead of using the fossils from the WH and losing the faunal data or reducing the sample size of the fauna, modern shark and ray teeth were obtained for the experiments. Modern teeth were also used because the fossil material invariably undergoes some fossilization process (diagenesis, permineralization, etc.), resulting in changes that could possibly render the current experiment moot. Unaltered modern teeth were acquired from an aquarium (Maritime Aquarium in Norwalk, CT).

Initially unaltered shark jaws were acquired from Sharkking.com based in Titusville, FL. They were submerged in a saltwater tank housing shrimp (courtesy of Shrimp Farm Market in Okemos, MI) to soften the cartilage and loosen the teeth. Teeth were released once the cartilage of the jaws was softened, and the cartilage was then subsequently eaten by the shrimp (Figure 73). The teeth produced were deemed unsuitable, as they were mostly not fully formed teeth displaying the morphological characteristics that would be needed to track throughout the experiment.

Once unaltered modern *Carcharias taurus* (shark) and *Rhinoptera bonasus* (ray) teeth were acquired, an apparatus was devised to tumble the teeth in such a manner as to be able to track every tooth. The system consisted of EduScience lapidary tumblers. Each tumbler was filled with a mixture of saltwater (utilizing R.O. water and Red Sea Salt, a commercially available salt for home aquariums housing tropical fish and invertebrates) and sand from the WH (which is very well-sorted, moderately rounded, medium to fine-grained, yellow-tan shoreface quartz sandstone [Rogers and Kidwell, 2000] with traces of feldspar and even smaller amounts of pyroxene/amphibole). Four teeth were placed into each of the eight tumblers (labelled A thru H), three *C. taurus* and one *R. bonasus* (teeth were initially assigned an alphanumeric identification number dependent on the barrel housing, example: tooth 1 in barrel A is named A1, to retain identity throughout the experiment (Figure 74). The teeth were later given catalogue numbers (SMM P2006:15:1:1- SMM P2006:15:8:4 H4) for eventual housing at the SMM. The quantity of teeth per tumbler was chosen to increase the ability to track each tooth as it changed during the course of the experiment. Preliminary experiments in 2005 proved that such a set up was needed. The preliminary trial in 2004-2005 consisted of one lapidary tumbler with 25 *C. taurus* teeth that were marked, only to lose all form of identification after 200 hours of tumbling. The abrasive nature of the experiment would cause any form of mark on the teeth to be erased. Selection of the teeth placed into each tumbler was primarily based on the overall morphology and completeness of each tooth, making each tooth recognizable from the others after each tumbling interval. As stated above, this was necessary because a tooth could not be labelled in any manner and retain that label through the duration of the experiment. The total sample size used here was 24 *C. taurus* teeth and 8 *R. bonasus* teeth.

The teeth were tumbled in the sand and water mixture for a total of 1000 hours, approximately equivalent to a linear distance of 880 kilometers based on the barrel dimensions, rpm, and duration of the experiment, during the summer of 2006. Revolutions per minute (rpm) for each tumbler were monitored multiple times a day (total of 78 times) as they varied throughout the run of the experiment. At 50 hour intervals the teeth were measured (height and width in millimeters with Mitutoyo Digimatic Calipers [500-351] and mass in grams with a Mettler College244 Delta Range Balance) and photographed, both labial and lingual sides (with an 8.0 megapixel 8x zoom Nikon Coolpix 8700 digital camera; photos of the tumblers were taken with an Olympus Camedia C-3000 Zoom Digital Camera) to monitor any changes between runs. Images of the teeth were placed (using PhotoShop) on a uniform black background and all numerical and qualitative data were saved in Excel and later manipulated for statistical tests.

Results

Qualitative results

Visual changes in the teeth were noticeable. Teeth from both *Carcharias taurus* and *Rhinoptera bonasus* started out white in color. After the first 50 hours of tumbling they showed a color change in the root, from white to a yellow/tan color (Figures 75-78). The cusp retained the white color for the duration of the experiment however, early on some of the teeth developed a gray undertone. Some of the teeth showed a dramatic change after the first 50 hours of tumbling. Tooth A2 (*C. Taurus*) lost 2.00 millimeters in height after 50 hours of tumbling, whereas some teeth showed very little change. Some teeth showed an impressive change in sharpness, going from very sharp to quite dull, where other teeth retained virtually the same sharpness at 500 hours. So far no quantitative method has been devised for measuring sharpness though there are methods for mammal teeth (Lucas, 2004) and tools (razors, knives, etc.). Currently the change in sharpness is based on tactile differences until such a scale can be determined. Figures 75-78 show a series of one tooth (A2) of *Carcharias taurus*, from time 0 hours to time 1050 hours in lingual view. For all tooth series see Appendix G.

Quantitative results

Carcharias taurus

Sample data for height loss of tooth A2 is in Table 15 (all data for height, width, and mass loss for all teeth in the experiment are in Appendix H). Rates of loss were measured in mm/hr for height and width and g/hr for the mass. The approximate rates of loss are (linear regression), height: 0.0025 mm/hr, width: 0.0026 mm/hr, and mass: $4e^{-5}$ g/hr (Table 16a), where one hour of travel is approximated to be 0.879 km. Mean values of measurements (height, width, and mass) for all teeth (n = 24 [shark]) were taken at 50 hour intervals throughout the entire 1000 hour length of the experiment and varied significantly (minimum p = 0.0005). Table 16b presents the exponential "rate of change" for the teeth.

Rhinoptera bonasus

The approximate rates of loss are height (linear regression): 0.0002 mm/hr, width: 0.0002 mm/hr, and mass: $7e^{-6}$ g/hr (Table 16a). Mean values of measurements (height, width, and mass) for all teeth (n = 8 [ray]) were taken at 50 hour intervals throughout the entire

1000 hour length of the experiment and varied significantly (minimum $p = 0.0005$). Table 16b presents the exponential "rate of change" for the teeth.

Significance correlation and Student's t-tests

Changes were measured statistically with the Pearson product-Moment Correlation and Student's t-test. Regression analysis (using Microsoft Excel) produced a best fit line through the data. Linear regression and regression exponential curves were both carried out. The correlation coefficient (r) measures the goodness of fit of the points to the line (e.g. Figures 79 and 80). The significance of "r" is then found in a probability table with the known degrees of freedom from the experiment and the intersection of those two variables on the table determines the level of significance for the data (Fisher, 1954: 209). Linear and exponential equations of best fit lines were calculated through Excel for all of the teeth over time. The samples in Tables 17 and 18 provide the line equation, slope of the line or the power function for the exponential regression (rate of change), the r^2-value, the r-value, and degrees of freedom (all data in Appendix I). Individually and as a whole (population) teeth of *C. taurus* had a 99% (both linear and exponential) significance correlation for height, width, and mass whereas *R. bonasus* had a significance correlation of 98% for height (as a population) and anywhere from 90%-99% for individual teeth (linear, 99% for exponential), 98% (linear, 99% exponential) as a whole population for width (and anywhere from 90%-99% for individual teeth linear, 99% exponential), and 99% for the whole population for mass (linear and exponential), with one tooth at 95% and one tooth not significant at any level (linear, and all but one tooth 99% exponential) (Tables 19a-b; all data in Appendix I is the same format as Tables 17 and 18).

The Student's t-tests can be used to assess the significance between populations, or the "before" and "after" affect of a treatment, where "before" and "after" are the populations and the hypothesis is that there is no significant difference in the "before" and "after" populations. Sample Student's t-test results for the change in height or height loss for *C. taurus* in Table 20 show that were all at $p = 0.0005$ (for all variables, height, width, and mass) but the results were more variable for *R. bonsaus*, ranging $p = 0.01$-0.001 (Table 21). Results for the ray teeth were far more erratic than they were for the shark teeth (see Appendix I for graphs). For all the Student's t-test data see Appendix J. The results for correlation and the Student's t-test would imply that the null hypothesis, there is no change in preservation with time in a dynamic environment, should be rejected.

Interpretations

Changes in tooth appearance demonstrate qualitatively that physical abrasion does indeed alter the teeth (Figures 75-78). It was also demonstrated statistically, by means of significance correlation and Student's t-tests that putting shark and ray teeth in a simulated dynamic environment, the simulation will alter them greatly. The shark teeth showed exceptionally consistent results throughout the run of the experiment. The ray teeth however showed greater variability. One reason for this is sand from the tumbling mixture lodging in the comb-like root of the teeth, altering the mass and introducing a source of variation. Additionally, consistency was difficult to maintain with linear measurements for the ray teeth. It should also be noted that there are no real projections to be worn down on the ray teeth. They are compact structures and very different from the shark teeth that have cusps, cusplets, and root lobes vulnerable to breaking. Due to the scale of the teeth and instrumentation used it is not possible to report how much the "teeth" of the comb were worn down. Overall the ray teeth showed less change relative to the shark teeth.

Application of taphonomy experiments to the JRF fauna

This analysis can also apply to differences between the WH and PPF bonebeds within the JRF. Given their close proximity (approximately 3 kilometers) and that they represent the same shoreface deposits and stratigraphic horizon, with nearly identical faunal diversity, it was rather surprising to see a difference in the overall preservation between the two sites. Differential abundances and preservation would appear to suggest that other, as yet unrecognized, factors differentially impacted the two sites.

The WH has 18 taxa and PPF 16 taxa (Table 9) with very similar faunal compositions. However, the WH has a greater abundance of material and a wider array of preservation (from 21 kilograms of matrix), whereas the PPF shows less abundance (from 45 kilograms of matrix) with more uniform preservation (Figures 71 and 72 and Tables 22 and 23). This suggests localized areas of variable energy, with the WH site representing a higher energy environment bringing in additional material (e.g. chimaerids) from farther offshore and mixing it with local material, and abrading the specimens to a higher degree than those preserved at PPF, where the material reflects a more autochthonous origin. Figures 71 and 72 show the range of preservation between the bonebeds. A qualitative listing of the range of preservation between bonebeds (Table 22) shows that

WH has a broader range of preservation than PFF. Original "Pristine" WH teeth have some degree of rounding of the cusps, cutting edges, and/or root, otherwise surficial details on the whole, preserved. The teeth may be broken through the root, or all identification of a tooth is lost when all that remains are tips, broken cusps, broken roots, and fragmentary chimaerid plates. "Pristine" PPF teeth turned out to be very pristine, then teeth with some breakage, and then little else left for identification. Table 23 lists the fauna and quantity of elements of each taxon found in each bonebed. PPF has far less material overall with approximately 64% of the WH total. *Protoplatyrhina renae* is by far the most abundant fossil (teeth and dermal denticles) found in both bonebeds, accounting for ~66% of the material for WH and ~80.1% of the material for PPF. However the abundances of each taxon differs after that (Table 24). Also listed in Table 23, is the material screen washed in the field by RRR, illustrating that screen washing on site produces far less material than bulk sampling and dry sieving in a laboratory. Screen washing of WH matrix produced 10.5% of the material than was produced from WH through dry sieving, clearly demonstrating that screen washing on site creates a great loss of material and information.

Taphonomic scale

The initial taphonomic scale (Table 10) for shark teeth based on the *Archaeolamna kopingensis* teeth from the WH proved to be insufficient to describe the additional range of preservation seen in the teeth from PPF. After examining additional fossil material of greater preservational range, Tables 12a-b expands upon the preservational range, but still only in a qualitative manner. With the information from the qualitative categories and the experimental work, a new taphonomic scheme can be proposed. Proposed here is a scale using a 1-10 scale with 1 being "pristine," in this case a pristine tooth, and 10 being "featureless," a tooth ground down to a pebble. Table 25 is proposed as a new taphonomic scale to use in assessing the quality of preservation of fossil shark teeth. Figure 81 shows how modern teeth (from the experiment) and fossil teeth (from WH and PPF) may fit in with the scheme with the exception of the coloration for the fossil teeth. This scale describes the loss of diagnostic features as witnessed in the experiments, starting with a complete, pristine, sharp, tooth, slight blunting of the cusp and discoloration is the first real sign. This is followed by rounding of the root lobes. As wear progresses the tooth becomes increasingly more blunt, roots more absent, and cusplets completely worn away. The final stage is a featureless stage where the tooth no longer resembles an organic entity. There are current limitations to this proposed scheme as it is applicable to teeth that have been worn down but not broken. Another limitation at this time is the duration of the experiment; clearly to achieve a featureless pebble will require many hours beyond the 1000 hours to achieve.

These observations and experimental results reveal intrinsic links between paleodiversity and taphonomy and are likely applicable to other sites exhibiting discrete lag deposits. Fossils that are most likely autochthonous are those that display little to no abrasion and those that do would be allochthonous as evidenced by the tumbling experiment. The varying range of preservation and faunal compositions between locally close sites would also indicate that sampling just one site is not sufficient to gather enough information for a comprehensive view of the fauna of an area.

	Pristine (patchy coloration)		Root minimally abraded crown patchy coloration		Pristine (crown tip broken)		Root abraded w/ coloration		Broken		Broken patchy coloration		TOTAL	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Anterior	7	14.6	-	-	-	-	1	2.1	4	8.3	6	12.5	18	37.5
Lateral	5	10.4	4	8.3	-	-	-	-	-	-	2	4.2	11	22.9
Posterior	6	12.5	2	4.2	1	2.1	-	-	9	18.8	1	2.1	19	39.6
	#	%	#	%	#	%	#	%	#	%	#	%		
TOTAL	18	37.5	6	12.5	1	2.1	1	2.1	13	27.1	9	18.8	**48**	**100.0**

Table 10. Initial characterization of tooth taphonomy based on *Archaeolamna kopingensis* from the Woodhawk Bonebed.

	Pristine (patchy coloration)		Root minimally abraded crown patchy coloration		Pristine (crown tip broken)		Root abraded w/ coloration		Broken		Broken patchy coloration		TOTAL	
	o	e	o	e	o	e	o	e	o	e	o	e	o	e
Anterior	7	6.8	-	2.3	-	0.4	1	0.4	4	4.9	6	3.4	18	18
Lateral	5	4.1	4	1.4	-	0.2	-	0.2	-	3.0	2	2.1	11	11
Posterior	6	7.1	2	2.4	1	0.4	-	0.4	9	5.1	1	3.6	19	19
	o	e	o	e	o	e	o	e	o	e	o	e		
TOTAL	18	18.0	6	6.0	1	1.0	1	1.0	13	13	9	9.0	**48**	**48**

Chi square test results: 0.31861 (anterior)
0.1245 (lateral)
0.27954 (posterior)

Table 11. Observed and expected occurrences and X^2-test of teeth from Table 10.

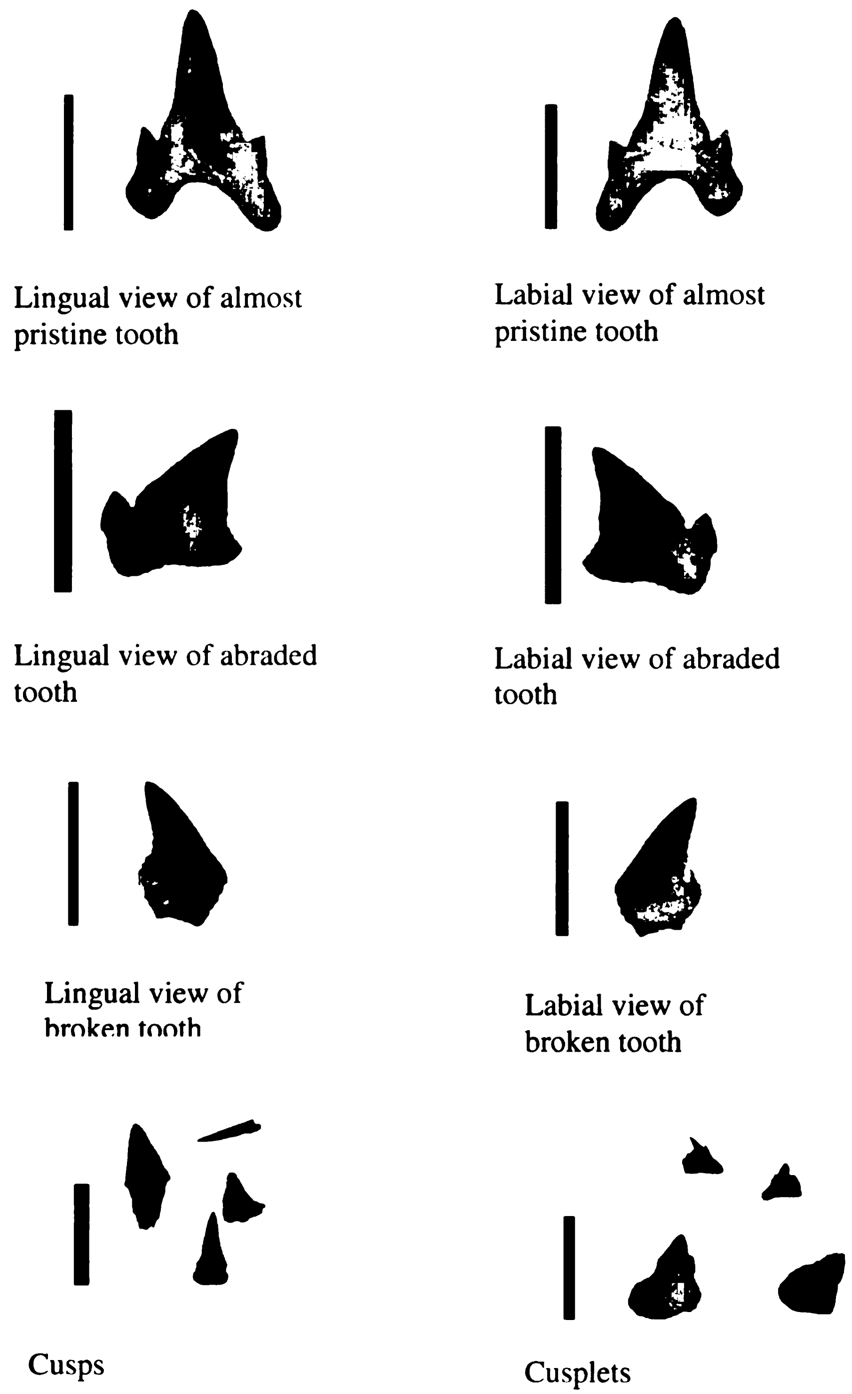
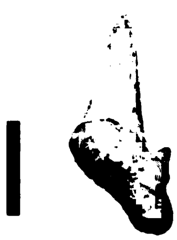


Figure 71. Preservational range of *Archaeolamna kopingensis* from the Woodhawk Bonebed. Scale bar = 1.0 cm.

Lingual view of
pristine tooth

Labial view of
pristine tooth



Lingual view of pristine
but broken tooth

Labial view of pristine but
broken tooth

Figure 72. Preservational range of *Archaeolamna kopingensis* from the Power Plant Ferry Bonebed. Scale bar = 1.0 cm.

Table 12a.

WH	Pristine #	Pristine %	Almost pristine may have patchy coloration #	Almost pristine may have patchy coloration %	Pristine but crown tip broken #	Pristine but crown tip broken %	Root minimally abraded may have patchy coloration #	Root minimally abraded may have patchy coloration %	Root abraded may have patchy coloration #	Root abraded may have patchy coloration %	Broken may have patchy coloration #	Broken may have patchy coloration %	Cusplets #	Cusplets %	TOTAL #	TOTAL %
Anterior	-	-	8	10.4	4	5.2	3	3.9	2	2.6	5	6.5			22	28.6
Lateral	-	-	10	13.0	-	-	-	-	1	1.3	6	7.8			17	22.1
Posterior	-	-	11	14.3	2	2.6	1	1.3	-	-	10	13.0	14	18.2	24	49.4
TOTAL	0	0	29	37.7	6	7.8	4	5.2	3	3.9	21	27.3	14	18.2	**77**	**100.0**

Table 12b.

PPF	Pristine #	Pristine %	Almost pristine may have patchy coloration #	Almost pristine may have patchy coloration %	Pristine but crown tip broken #	Pristine but crown tip broken %	Root minimally abraded may have patchy coloration #	Root minimally abraded may have patchy coloration %	Root abraded may have patchy coloration #	Root abraded may have patchy coloration %	Broken may have patchy coloration #	Broken may have patchy coloration %	Pristine but cusp or root only #	Pristine but cusp or root only %	TOTAL #	TOTAL %
Anterior	5	11.1	1	2.2	1	2.2	-	-	1	2.2	9	20	2	4.4	19	42.2
Lateral	-	-	-	-	1	2.2	2	4.4	1	2.2	15	33.3	1	2.2	20	44.4
Posterior	3	6.7	-	-	-	-	-	-	-	-	3	6.7	-	-	6	13.3
TOTAL	8	17.8	1	2.2	2	4.4	2	4.4	2	4.4	27	60	3	6.7	**45**	**100.0**

Table 12a. Revised characterization of tooth taphonomy based on *Archaeolamna kopingensis* from the Woodhawk Bonebed (included are teeth screenwashed on site by RRR). Table 12b. Revised initial characterization of tooth taphonomy based on *Archaeolamna kopingensis* from the Power Plant Ferry Bonebed.

Table 13a.

WH	Pristine o	Pristine e	Almost pristine may have patchy coloration o	Almost pristine may have patchy coloration e	Pristine but crown tip broken o	Pristine but crown tip broken e	Root minimally abraded may have patchy coloration o	Root minimally abraded may have patchy coloration e	Root abraded may have patchy coloration o	Root abraded may have patchy coloration e	Broken may have patchy coloration o	Broken may have patchy coloration e	**Cusplets** **o**	**Cusplets** **e**	TOTAL o	TOTAL e
Anterior	-	-	8	10.1	4	2.1	3	1.4	2	1.0	5	7.3			22	22.0
Lateral	-	-	10	7.8	-	1.6	-	1.1	1	0.8	6	5.7			17	17.0
Posterior	-	-	11	11.0	2	2.3	1	1.5	-	1.1	10	8.0	**14**		24	24.0
TOTAL	0	0.0	29	29.0	6	6.0	4	4.0	3	3.0	21	21.0			63	63

Chi square test results: 0.22893 (anterior)
0.49844 (lateral)
0.76164 (posterior)

Table 13b.

PPF	Pristine o	Pristine e	Almost pristine may have patchy coloration o	Almost pristine may have patchy coloration e	Pristine but crown tip broken o	Pristine but crown tip broken e	Root minimally abraded may have patchy coloration o	Root minimally abraded may have patchy coloration e	Root abraded may have patchy coloration o	Root abraded may have patchy coloration e	Broken may have patchy coloration o	Broken may have patchy coloration e	Pristine but cusp or root only o	Pristine but cusp or root only e	TOTAL o	TOTAL e
Anterior	**5**	**3.4**	**1**	**0.4**	**1**	**0.8**	-	**0.8**	**1**	**0.8**	**9**	**11.4**	2	0.0	**19**	**17.7**
Lateral	-	**3.6**	-	**0.4**	**1**	**0.9**	**2**	**0.9**	**1**	**0.9**	**15**	**12.0**	1	0.0	**20**	**18.7**
Posterior	**3**	**1.1**	-	**0.1**	-	**0.3**	-	**0.3**	-	**0.3**	**3**	**3.6**	-	0.0	**6**	**5.6**
TOTAL	8	8.0	1	1.0	2	2.0	2	2.0	2	2.0	27	27			45	42

Chi square test results: 0.75703 (anterior)
0.39585 (lateral)
0.55207 (posterior)

Table 13a. Observed and expected occurrences of teeth from Table 12a (cusplets are excluded from analysis as position is indeterminate). Table 13b. Observed and expected occurrences of teeth from Table 12b.

Table 14a.

WH	Pristine	Almost pristine may have patchy coloration	Pristine but crown tip broken	Root minimally abraded may have patchy coloration	Root abraded may have patchy coloration	Broken may have patchy coloration	**Cusplets**	TOTAL
Anterior	-	8	4	3	2	5		22
Lateral	-	10	-	-	1	6		17
Posterior	-	11	2	1	-	10	**14**	24
TOTAL	0	29	6	4	3	21	**14**	63

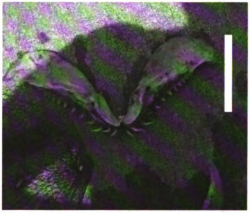
Table 14b.

PPF	Pristine	Almost pristine may have patchy coloration	Pristine but crown tip broken	Root minimally abraded may have patchy coloration	Root abraded may have patchy coloration	Broken may have patchy coloration	**Pristine but cusp or root only**	TOTAL
Anterior	5	1	1	-	1	9	**2**	17
Lateral	-	-	1	2	1	15	**1**	19
Posterior	3	-	-	-	-	3	**-**	6
TOTAL	8	1	2	2	2	27	**3**	42

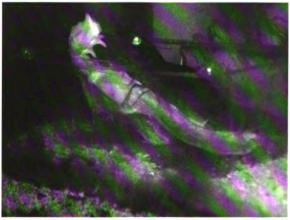
Chi square test results:		
	Total	1.5411E-06
	Anterior	0.0059169
	Lateral	0.0021158
	Posterior	0.0036427

Table 14a. *Archaeolamna kopingensis* from the Woodhawk Bonebed. Table 14b. *Archaeolamna kopingensis* from the Power Plant Ferry Bonebed. Categories in bold was omitted from the X^2-test.

Modern shark jaw pre-
immersion in salt water tank



Shark jaw after immersion in salt water
tank



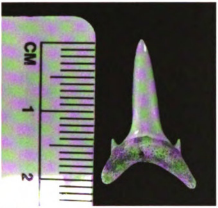
Modern shark jaw in salt water tank with
shrimp

Figure 73. Tooth procurement attempt. Scale bar = 10.0 cm.

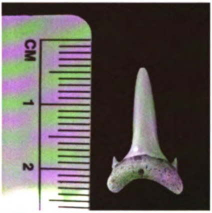
Individual barrel

Experiment line up

Figure 74. Taphonomic experimental set up. Consisting of 8 EduScience lapidary tumblers, salt water, sand from the JRF, and modern teeth of *Carcharias taurus* (shark) and *Rhinoptera bonasus* (ray).

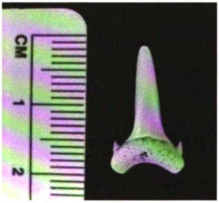


75a. 0 hours

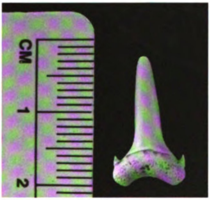


75b. 50 hours

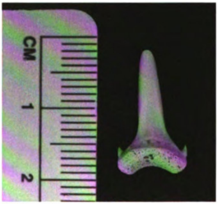
75c. 100 hours



75d. 150 hours



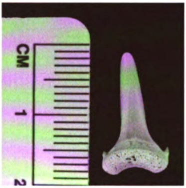
75e. 200 hours



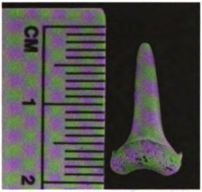
75f. 250 hours

Figure 75. Sample tooth (A2) of modern *Carcharias taurus* in lingual view, starting from time zero hours (a) to time 250 hours (f). Time increment 50 hours.

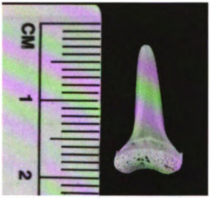
76a. 300 hours



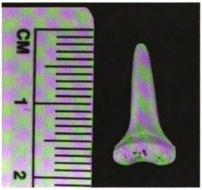
76b. 350 hours



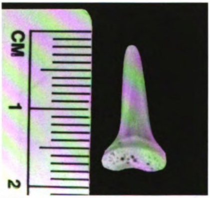
76c. 400 hours



76d. 450 hours

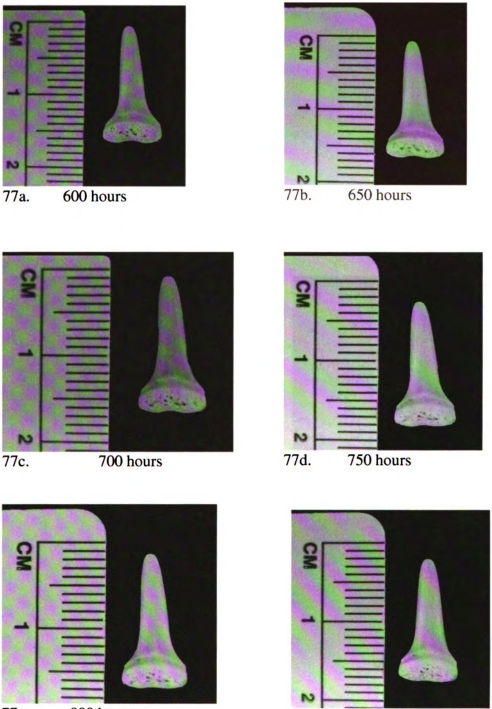


76e. 500 hours



76f. 550 hours

Figure 76. Sample tooth (A2) of modern *Carcharias taurus* in lingual view, starting from time 300 hours (a) to time 550 hours (f). Time increment 50 hours.



77a. 600 hours

77b. 650 hours

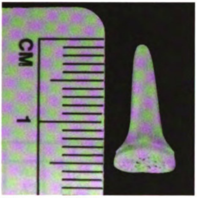
77c. 700 hours

77d. 750 hours

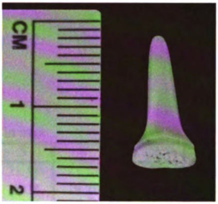
77e. 800 hours

77f. 850 hours

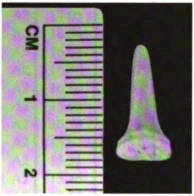
Figure 77. Sample tooth (A2) of modern *Carcharias taurus* in lingual view, starting from time 600 hours (a) to time 850 hours (f). Time increment 50 hours.



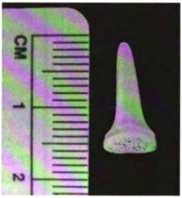
78a. 900 hours



78b. 950 hours



78c. 1000 hours



78d. 1050 hours

Figure 78. Sample tooth (A2) of modern *Carcharias taurus* in lingual view, starting from time 900 hours (a) to time 1050 hours (d). Time increment 50 hours.

Tooth A2, Height in mm

		1	2	3	4	5	6	ST DEV	Average
0	A2	21.15	21.13	21.14	21.14	21.14	21.13	0.0075	21.14
50	A2	19.29	19.30	19.30	19.29	19.28	19.28	0.0089	19.29
100	A2	18.77	18.76	18.77	18.76	18.75	18.75	0.0089	18.76
150	A2	17.96	17.99	17.96	17.97	17.98	17.98	0.0121	17.97
200	A2	17.36	17.38	17.34	17.34	17.36	17.37	0.0160	17.36
250	A2	17.12	17.12	17.15	17.14	17.14	17.12	0.0133	17.13
300	A2	17.05	17.07	17.07	17.05	17.06	17.06	0.0089	17.06
350	A2	16.94	16.93	16.93	16.93	16.92	16.93	0.0063	16.93
400	A2	16.68	16.68	16.68	16.69	16.68	16.67	0.0063	16.68
450	A2	16.40	16.37	16.37	16.35	16.35	16.38	0.0190	16.37
500	A2	16.10	16.10	16.11	16.11	16.12	16.09	0.0105	16.11
550	A2	15.95	15.95	15.95	15.95	15.95	15.95	0.0000	15.95
600	A2	15.78	15.78	15.77	15.79	15.78	15.78	0.0063	15.78
650	A2	15.67	15.67	15.67	15.67	15.67	15.66	0.0041	15.67
700	A2	15.51	15.51	15.49	15.60	15.51	15.50	0.0400	15.52
750	A2	15.46	15.45	15.44	15.44	15.45	15.44	0.0082	15.45
800	A2	15.35	15.34	15.35	15.35	15.35	15.34	0.0052	15.35
850	A2	15.29	15.29	15.29	15.28	15.29	15.29	0.0041	15.29
900	A2	15.26	15.25	15.25	15.24	15.23	15.24	0.0105	15.25
950	A2	15.20	15.21	15.20	15.21	15.20	15.20	0.0052	15.20
1000	A2	15.13	15.13	15.16	15.18	15.19	15.18	0.0264	15.16

Table 15. Height change (mm) of sample tooth of modern *Carcharias taurus* (taphonomy series). Six replicates of each dimension measured at each interval. Tooth A2 height measurements with standard deviation and average for each interval.

Table 16a.

Linear	Height loss (mm/hr)	Width loss (mm/hr)	Mass loss (g/hr)
Carcharias taurus	0.0025	0.0026	0.00004
Rhinoptera bonasus	0.0002	0.0002	0.000007

Table 16b.

Exponential	Height loss (mm/hr)	Width loss (mm/hr)	Mass loss (g/hr)
Carcharias taurus	^-0.067	^-0.1045	^-0.1062
Rhinoptera bonasus	^-0.0225	^-0.0051	^-0.0233

Table 16a. Approximate rates of loss (height, width, and mass) for *Carcharias taurus* and *Rhinoptera bonasus* (Linear Regression). Table 16b. Approximate rates of loss (height, width, and mass) for *Carcharias taurus* and *Rhinoptera bonasus* (Regression Exponential Curve).

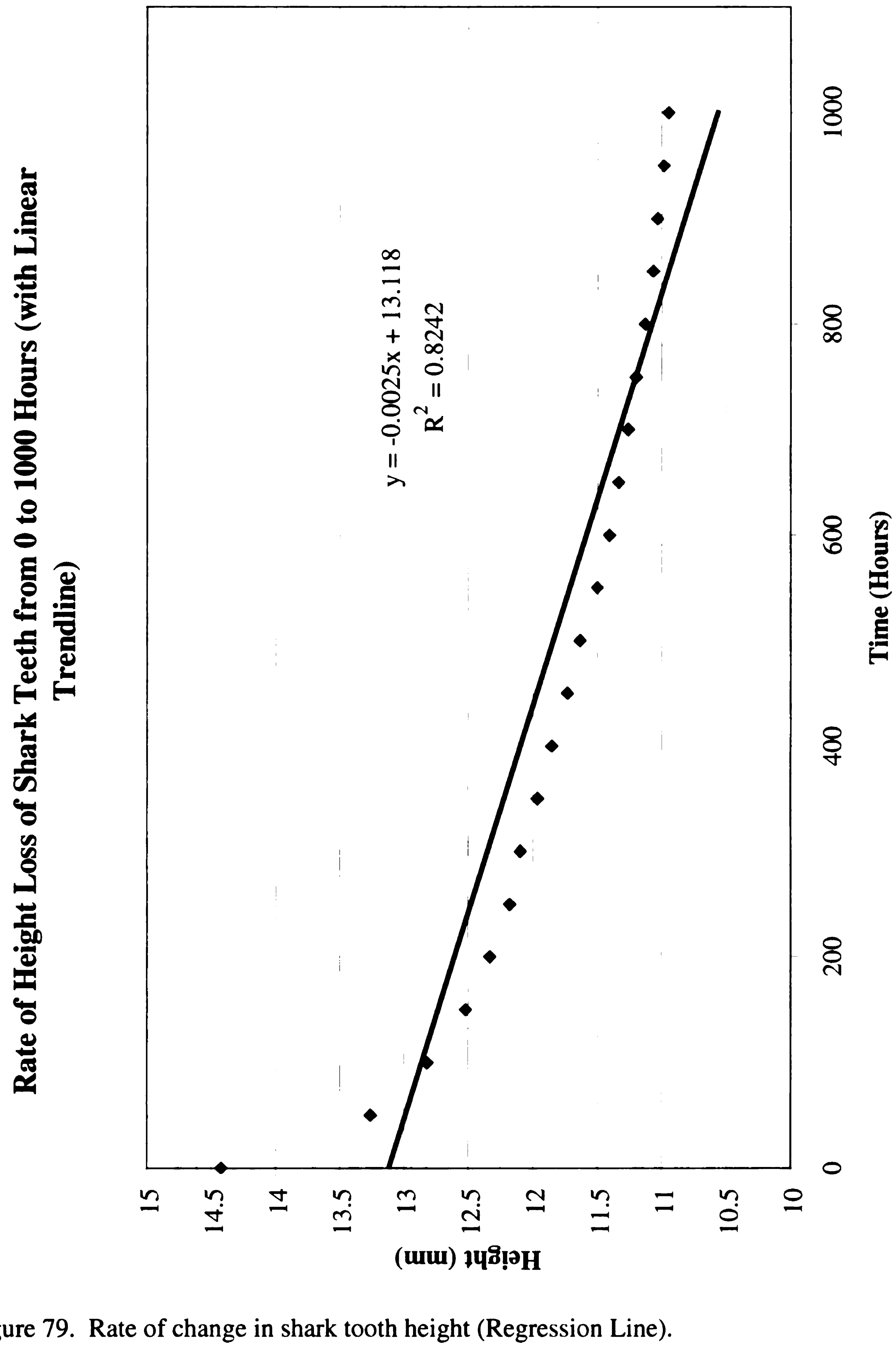


Figure 79. Rate of change in shark tooth height (Regression Line).

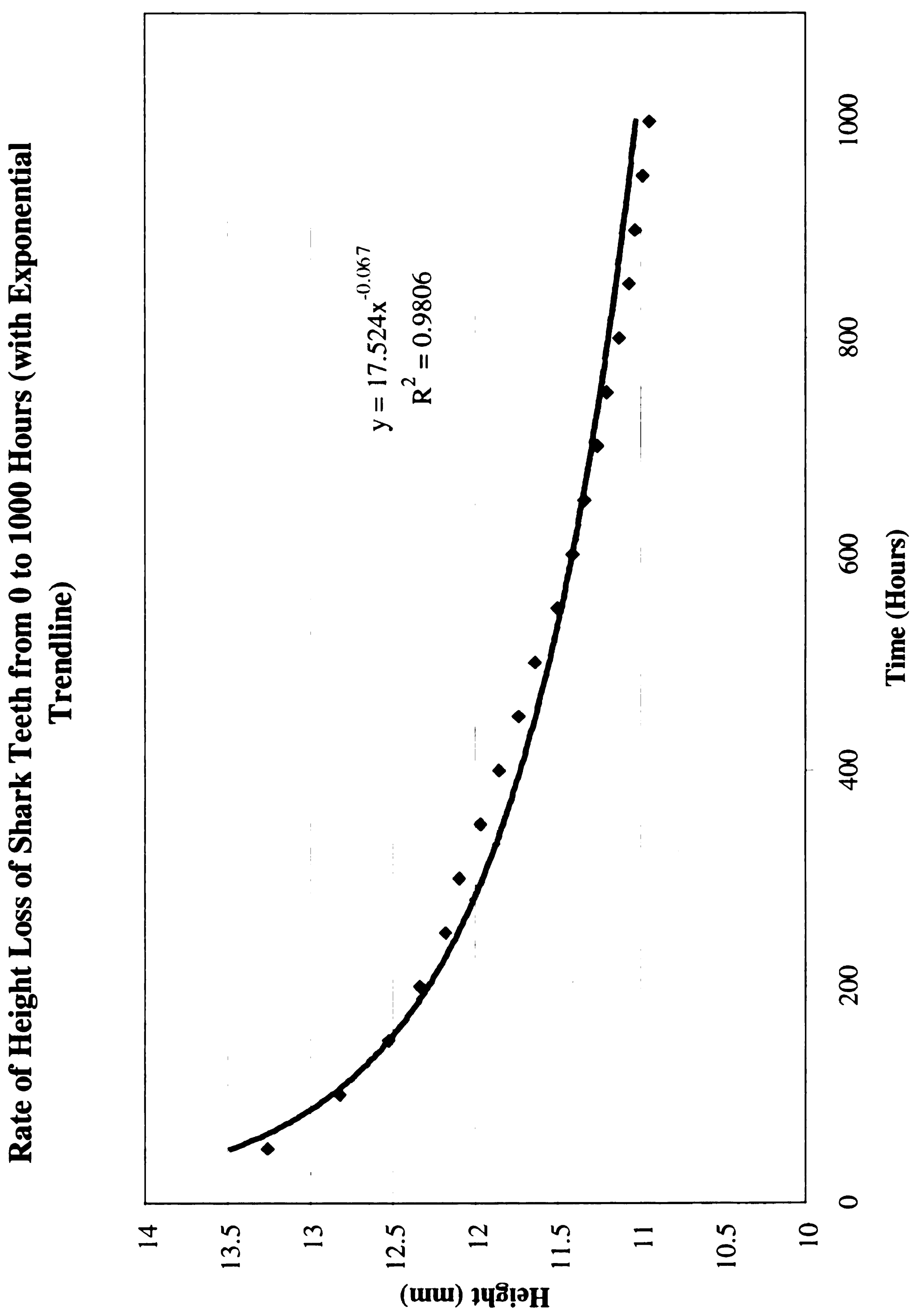


Figure 80. Rate of change in shark tooth height (Regression Exponential Curve).

Linear Regression

	Equation	m	R^2	R	df
A1	y = -0.0023x + 17.068	-0.0023	0.9594	0.97949	23
A2	y = -0.0046x + 18.926	-0.0046	0.8148	0.902663	23
A3	y = -0.0024x + 12.653	-0.0024	0.8273	0.90956	23
B1	y = -0.0014x + 7.9343	-0.0014	0.8975	0.947365	23
B2	y = -0.0026x + 12.559	-0.0026	0.8617	0.928278	23
B3	y = -0.0027x + 9.7489	-0.0027	0.9106	0.954254	23
C1	y = -0.0027x + 14.255	-0.0027	0.8645	0.929785	23
C2	y = -0.0022x + 11.964	-0.0022	0.8375	0.91515	23
C3	y = -0.0002x + 13.473	-0.0002	0.7848	0.885889	23
D1	y = -0.0025x + 12.013	-0.0025	0.8241	0.9078	23
D2	y = -0.0022x + 10.051	-0.0022	0.7919	0.889888	23
D3	y = -0.0028x + 16.689	-0.0028	0.5772	0.759737	23
E1	y = -0.0021x + 13.757	-0.0021	0.6659	0.816027	23
E2	y = -0.004x + 16.37	-0.004	0.7754	0.880568	23
E3	y = -0.0031x + 16.29	-0.0031	0.7419	0.861336	23
F1	y = -0.0018x + 10.081	-0.0018	0.8797	0.937923	23
F2	y = -0.0025x + 14.651	-0.0025	0.7417	0.86122	23
F3	y = -0.0051x + 11.451	-0.0015	0.8234	0.907414	23
G1	y = -0.0019x + 12.072	-0.0019	0.8568	0.925635	23
G2	y = -0.0034x + 13.599	-0.0034	0.8527	0.923418	23
G3	y = -0.0029x + 13.67	-0.0029	0.8683	0.931826	23
H1	y = -0.0021x + 10.98	-0.0021	0.779	0.88261	23
H2	y = -0.0022x + 11.074	-0.0022	0.9095	0.953677	23
H3	y = -0.0032x + 13.885	-0.0032	0.8656	0.930376	23
Average		-0.002471	0.8213	0.905079	

All Significant at 99%

Table 17. Correlation for shark (*Carcharias taurus*) tooth height loss (Linear Regression).

Exponential Regression

	Equation	^	R^2	R	df
A1	y = 21.071x^-0.0473	^-0.0473	0.9253	0.961925	23
A2	y = 27.812x^-0.0879	^-0.0879	0.9831	0.991514	23
A3	y = 16.921x^-0.0699	^-0.0699	0.9843	0.992119	23
B1	y = 10.371x^-0.0614	^-0.0614	0.9318	0.965298	23
B2	y = 17.182^-0.072	^-0.072	0.9671	0.983412	23
B3	y = 15.481x^-0.104	^-0.104	0.9559	0.977701	23
C1	y = 19.016x^-0.0662	^-0.0662	0.9662	0.982955	23
C2	y = 15.905x^-0.0653	^-0.0653	0.9816	0.990757	23
C3	y = 16.39x^-0.0468	^-0.0468	0.9669	0.983311	23
D1	y = 16.383x^-0.0716	^-0.0716	0.9809	0.990404	23
D2	y = 13.725x^0.073	^-0.073	0.9757	0.987775	23
D3	y = 20.684x^-0.0528	^-0.0528	0.9665	0.983107	23
E1	y = 16.414x^-0.0447	^-0.0447	0.9649	0.982293	23
E2	y = 23.484x^-0.0886	^-0.0886	0.9832	0.991564	23
E3	y = 21.005x^-0.0612	^-0.0612	0.9644	0.982039	23
F1	y = 13.267x^-0.0627	^-0.0627	0.9701	0.984937	23
F2	y = 18.598x^-0.057	^-0.057	0.9903	0.995138	23
F3	y = 13.88x^-0.0449	^-0.0449	0.968	0.98387	23
G1	y = 15.273x^-0.0545	^-0.0545	0.9599	0.979745	23
G2	y = 20.408x^-0.0925	^-0.0925	0.9794	0.989646	23
G3	y = 19.197x^-0.0768	^-0.0768	0.9814	0.990656	23
H1	y = 14.288x^-0.0624	^-0.0624	0.9746	0.987218	23
H2	y = 15.374x^-0.0736	^-0.00736	0.963	0.981326	23
H3	y = 20.139x^-0.0845	^-0.00845	0.9681	0.983921	23
Average		#DIV/0!	0.96885833	0.984276	

All Significant at 99%

Table 18. Correlation for shark (*Carcharias taurus*) tooth height loss (Exponential Regression).

Table 19a.

Linear

	Height loss	Width loss	Mass loss
Carcharias taurus	99%	99%	99%
Rhinoptera bonasus	99%	98%	99%

Table 19b.

Exponential

	Height loss	Width loss	Mass loss
Carcharias taurus	99%	99%	99%
Rhinoptera bonasus	99%	99%	99%

Table 19a. Significance correlation (height, width, and mass) for population of *Carcharias taurus* and *Rhinoptera bonasus* (Linear Regression). Table 19b. Significance correlation (height, width, and mass) for population of *Carcharias taurus* and *Rhinoptera bonasus* (Regression Exponential Curve).

t-Test: Paired Two Sample for Means

	0 Hours	50 Hours
Mean	14.42472222	13.25986111
Variance	9.335265137	7.228397564
Observations	24	24
Pearson Correlation	0.991143656	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.78368613	
P(T<=t) one-tail	9.03664E-11	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.80733E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	450 Hours	500 Hours
Mean	11.73479167	11.56357589
Variance	5.46610394	5.610436314
Observations	24	24
Pearson Correlation	0.988495651	
Hypothesized Mean Difference	0	
df	23	
t Stat	2.341197208	
P(T<=t) one-tail	0.0141273	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.0282546	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	1000 Hours
Mean	14.42472222	10.9475
Variance	9.335265137	5.03429686
Observations	24	24
Pearson Correlation	0.966171238	
Hypothesized Mean Difference	0	
df	23	
t Stat	16.07788018	
P(T<=t) one-tail	2.64974E-14	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	5.29947E-14	
t Critical two-tail	2.068654794	

Table 20. Student's t-Test results for tooth height loss for *Carcharias taurus*.

	Height loss	Width loss	Mass loss
Carcharias taurus			
Individually	p = 0.0005	p = 0.0005	p = 0.0005
Population	p = 0.0005	p = 0.0005	p = 0.0005

Rhinoptera bonasus			
Individually	p = 0.01-0.001	p = 0.01-0.001	p = 0.01-0.001
Population	p = 0.01-0.001	p = 0.01-0.001	p = 0.01-0.001

Table 21. Student's t-Test (height, width, and mass) for population of *Carcharias taurus* and *Rhinoptera bonasus*.

	Woodhawk Bonebed	Power Plant Ferry Bonebed
Very pristine		X
Fairly pristine	X	
Broken - partial roots	X	
Broken - both root lobes missing	X	
Cusps only, roots only	X	X
Cusplets	X	
Very fragmentary		X
and everything in between (dulled cutting edges, fragments,...)	X	
dermal denticles	X	X
prismatic cartilage	X	X
centra	X	X
friable chimaerid tooth plates	X	

Table 22. Qualitative preservational range by bonebed.

	WH	WHRRR	PPF	Total WH	Total WH & PPF
Hybodus montanensis	10	-	-	10	10
Cretorectolobus olsoni	67	13	8	80	88
Squalicorax kaupi	3	-	1	3	4
Squalicorax sp., cf. S. kaupi	1	-	1	1	2
Squalicorax pristodontus	-	-	4	-	4
Hypotodus grandis	10	-	18	10	28
Hypotodus spp.	63	-	19	63	82
Archaeolamna kopingensis	63	14	45	77	122
Cretolamna appendiculata	9	-	2	9	11
Protolamna sokolovi	8	-	2	8	10
Archaeotriakis rochelleae	-	-	2	-	2
Protoplatyrhina renae	574	46	442	620	1062
Protoplatyrhina renae (dermal denticles)	280	28	214	308	522
Squatirhina sp.	13	-	-	13	13
Ischyrhiza avonicola	1	-	-	1	1
Ischyrhiza mira	63	66	34	129	163
Ptychotrygon hooveri	10	1	5	11	16
Ptychotrygon triangularis	1	-	6	1	7
Sclerorhynchidae indet.	25	5	6	30	36
Myledaphus bipartitus	12	5	1	17	18
Myledaphus bipartitus (dermal denticles)	12	1	2	13	15
Ischyodus	35	-	-	35	35
dermal denticles	61	12	59	73	132
Paralbula casei	1	-	-	1	1
Crocodile	2	1	1	3	4
prismatic cartilage	5	-	25	5	30
tooth fragments	188	35	119	223	342
Enchodus?	3	5	3	8	11
centra	644	-	349	644	993
tapered teleost teeth	19	-	-	19	19
cap teleost teeth	35	1	-	36	36
shark spine?	-	-	6	-	6
possible turtle pieces	-	-	48	-	48
unidentified bone chunks	-	-	5	-	5
totals	2218	233	1427	2451	3878

Table 23. Total fossil elements by bonebed. WHRRR is the material collected by RRR from the Woodhawk Bonebed and screened in the field.

Woodhawk	%	Power Plant Ferry	%
Protoplatyrhina renae	44.16	Protoplatyrhina renae	54.43
Protoplatyrhina renae (dermal denticles)	21.94	Protoplatyrhina renae (dermal denticles)	26.35
Ischyrhiza mira	9.19	Archaeolamna kopingensis	5.54
Cretorectolobus olsoni	5.70	Ischyrhiza mira	4.19
Archaeolamna kopingensis	5.48	Hypotodus spp.	2.34
Hypotodus spp.	4.49	Hypotodus grandis	2.22
Sclerorhynchidae indet.	2.14	Cretorectolobus olsoni	0.99
Myledaphus bipartitus	1.21	Ptychotrygon triangularis	0.74
Squatirhina sp.	0.93	Sclerorhynchidae indet.	0.74
Myledaphus bipartitus (dermal denticles)	0.93	Ptychotrygon hooveri	0.62
Ptychotrygon hooveri	0.78	Squalicorax pristodontus	0.49
Hybodus montanensis	0.71	Cretolamna appendiculata	0.25
Hypotodus grandis	0.71	Protolamna sokolovi	0.25
Cretolamna appendiculata	0.64	Archaeotriakis rochelleae	0.25
Protolamna sokolovi	0.57	Myledaphus bipartitus (dermal denticles)	0.25
Squalicorax kaupi	0.21	Squalicorax kaupi	0.12
Squalicorax sp., cf. S. kaupi	0.07	Squalicorax sp., cf. S. kaupi	0.12
Ischyrhiza avonicola	0.07	Myledaphus bipartitus	0.12
Ptychotrygon triangularis	0.07		
Total	100	Total	100

Table 24. Percentage of elasmobranch taxa by bonebed in descending order.

Scale	Name	Description	Time in tumbler (hr)	Estimated distance (km)
1	Pristine	Tooth is complete, original color, and sharp	0	0
2	Sub-pristine	Slight wear, discoloration	25	22
3	Good	Shortening of root lobes	50	44
4	Standard	Noticeable blunting of cusp	100	88
5	Sub-standard	Root lobes more absent than present	250	220
6	Fair	Cusplets (if present on taxon) worn away	500-1000	440-880
7	Blunt	Cusp blunt, root lobes gone	-	-
8	Rootless	Root completely gone	-	-
9	Poor	Vestiges of cusp more absent than present	-	-
10	Featureless	Pebble	-	-

Table 25. Revised taphonomy scale for shark teeth.

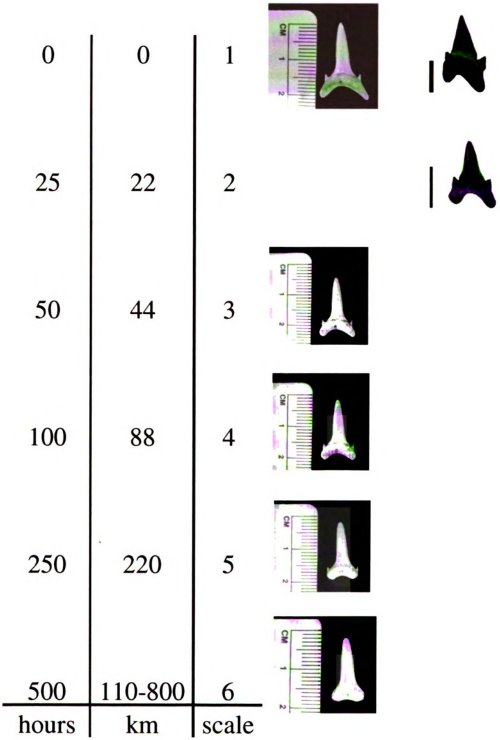


Figure 81. Modern and fossil shark teeth as how they may fit in a taphonomic scheme by time.

CHAPTER FIVE

SUMMARY AND CONCLUDING REMARKS

Six additional species were found that were previously unreported for the JRF: *Squalicorax pristodontus*, *Cretolamna appendiculata*, *Protolamna sokolovi*, *Ischyrhiza avonicola*, *Ptychotrygon hooveri*, and *Ptychotrygon triangularis*. The combined faunas from the WH and PPF bonebeds and Case's studies (1978a and 1979) indicate that the JRF was a coastal, warm shallow marginal marine environment host to a moderately diverse fauna of mostly lamniforms and rajiforms. Cluster analysis shows that 17 of the taxa from the JRF are endemic but they are more likely endemic to the end of the Cretaceous of the WIS: *Hybodus montanensis*, *Hybodus storeri*, *Synechodus andersoni*, *Synechodus striatus*, *Cretorectolobus olsoni*, *Eucrossorhinus microcuspidatus*, *Hypotodus grandis*, *Hypotodus* spp., *Odontaspis sanguinei*, *Archaeolamna kopingensis*, *Archaeotriakis rochelleae*, *Protoplatyrhina renae*, *Squatirhina* sp., *Ischyrhiza mira*, *Ptychotrygon blainensis*, Sclerorhynchidae indet., and *Myledaphus bipartitus*. Also present in this fauna are the cosmopolitan species: *Cretolamna appendiculata*, *Protolamna sokolovi*, *Ischyrhiza* sp., *Ptychotrygon hooveri* and *Ptychotrygon triangularis*. The species compositions of Case's studies and this study differ; however, the combined faunas produce a more comprehensive faunal list that is on par with contemporaneous faunas from similar environments from the JRF. The JRF fauna is part of the Judith River Formation Province, of which the faunas from the Dinosaur Park Formation (Alberta), Mesaverde Formation" (Wyoming), and the Hell Creek Formation (Montana) are a part, based on a generic level PAE.

The cosmopolitan and endemic composition of the fauna is mostly autochthonous (chimaerids and some of the rays are probably allochthonous). Material found *in situ* is likely to be less abraded than material brought in, as evidenced by the taphonomic experiments, experiments that also show, that despite having two locations fairly close to each other they can still vary in environment. The sites are localized areas of variable energy represented by the slight faunal changes, the abundance of material found, and the degree of preservation. The WH site represents a higher energy environment bringing in additional material from farther offshore and mixing it with local material, and abrading the specimens to a higher degree than those preserved at PPF, where the material reflects a more autochthonous origin. This creates a mixture of marine and estuarine fossils, which produces mixed interpretations of the geology and paleontology of the JRF. The experimental approach applied here provides insight on: (1) distinguishing the autochthonous from allochthonous fossil vertebrate hard parts, (2) quantifying the amount of transport and wear, and (3) illustrating the potential of postmortem effects to cause the loss or distortion of diagnostic skeletal features; in the case of shark teeth, the root lobes and apex of the cusp wear down first, followed by other projections such as cusplets. Loss of these features may inform one of taphonomic processes at play, but the gain of taphonomic information means loss of information on the taxon and overall the fauna. A preliminary product from these observations and experiments is a taphonomic scale that can be applied to moderately worn shark teeth. The scale devised here has 1 equaling "pristine" and 10 equaling "featureless." However the work here has only been able to achieve a 6 ("fair") on this scale where the teeth are worn and have lost their cusplets. More work is needed to reach the "featureless" stage.

Work for the future: More sites need to be found to better assess the range of paleoenvironments and faunal variations, not just within the JRF of Montana, but also throughout the WIS. Questions that can be asked: is there a wide variety of local paleoenvironments out there or is it finite? Do paleoenvironments change with location? With time?

Experimental work should continue as plenty of questions arose during this study that could not be addressed within the scope of this project. Additional tumbling studies would be beneficial. They could be done to mimic different environmental conditions. The JRF material comes from a clastic rich environment, what happens when clast size changes? What happens when clasts are removed and the water chemistry has changed? What about clast sizes and changing water chemistry? Different sediments from different localities would need to be collected, and water chemistries simulated. The current study only used sediment directly from the JRF and standard salt water (based on the Red Sea Salt recipe for aquaria) to best mimic the environment of the JRF sharks and overall limit variables.

The teeth used in any experiments would also have to be altered. What happens when different shaped shark teeth are used? This would be quite difficult to test, unaltered modern shark teeth are difficult to acquire. When available they have come from aquaria, but the variety of species is quite limited. What happens when broken teeth are used? Do the fractured/broken edges wear down like the teeth in this study or would they fracture further? If possible, the age of sharks producing the teeth would be useful to test against. How do older shark teeth differ from younger shark teeth (after factoring in ontogenetic heterodonty, if present)? Do they differ at all? What about fe/male sharks, would there be a difference between them (with factoring in sexual heterodonty, if present)? Diet may be a big factor, in which case, age and sex may be effected. What about teeth collected during different seasons? Again, this could be diet driven. Material can be reworked after fossilization, so fossil shark teeth should also be examined (the current study only used modern (extant), intact sharp, teeth in order to limit the variables), how do they compare to the modern teeth in weathering experiments?

Additionally, wave action models would be a more appropriate simulation for abrading teeth and should be employed (with the above variations of sediment, water chemistry, and teeth). With such a set up, different wave and coastal conditions can be mimicked, further exploring natural scenarios. Shark cartilage preservation is also an interesting topic to explore as it does not readily preserve in the fossil record. Fossilized pieces were found at both WH and PPF. The modern shark jaws placed in tanks with shrimp (for tooth extraction/procurement), at the Shrimp Farm Market were eaten by the shrimp (*Penaeus vannamei* – Pacific white shrimp), which are scavengers. To discount any breakdown of the cartilage by the water alone, jaws were also placed in tanks of salt water for weeks to months and showed no decay or degradation, only the loss of rigidity in the cartilage. As current experiments focused on physical abrasion of the teeth, chemical and biological experiments would be other avenues to explore.

Root studies are in their infancy right now. It has largely been assumed that any striations and/or grooves on any fossils are the result of roots. However, to date there is only one pilot study on the subject. Shark teeth can be utilized in this line of work to determine if native vegetation (ex. prairie grass) in Montana is altering the shark teeth in the field, and is there any difference between modern and fossil teeth? Another interesting idea that will be difficult to test, is how digestive acids of sharks (or other animals) effect teeth. This would follow teeth, whether they had been shed and swallowed, or had been eaten by another shark or animal, through the digestive system. Presumably there would be etching of the teeth from the digestive acids, but would there be anything left? Would there in fact be any etching? How do different animals' systems compare in the digestion of shark teeth? Another matter to explore is diagenesis. Select teeth were sent back to RRR for sectioning and study but there have been no results to report back on yet. Diagenetic and isotopic studies can also be carried out on both modern and fossil shark teeth, to see if it is possible to determine at what point a tooth goes from being "modern" to "fossil." Lastly, current work is being done to measure the change in sharpness of the teeth and possible methods are currently being sought out for testing.

DIVERSITY, BIOGEOGRAPHY, AND TAPHONOMY OF LATE CRETACEOUS CHONDRICHTHYANS FROM MONTANA

VOLUME II

By

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APPENDICES

APPENDIX A

WESTERN INTERIOR SEAWAY GENERA DATA FOR HIERARCHICAL CLUSTER ANALYSIS

	MT_Judith_River_Formation	MT_Hell_Creek_Formation	WY_"Mesaverde_Formation"	WY_Lance_Formation	ND_Hell_Creek_Formation	SD_Carlile_Shale	SD_Greenhorn_Formation	CO_Greenhorn_Limestone	AB_Judith_River_Formation	AB_Dinosaur_Park_Formation	SK_Judith_River_Formation	SK_Niobrara_Formation	KS_Carlile_Shale_Formation	KS_Niobrara_Chalk	AZ_Greenhorn_Cyclothem	TX_Woodbine_Group	TX_Eagle_Ford_Group	TX_Austin_Group	TX_Taylor_Group	TX_Navarro_Group
Hybodus	1	0	1	0	0	0	0	0	1	1	0	0	0	0	1	1	1	1	0	0
Lissodus	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Polyacrodus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Ptychodus	0	0	0	0	0	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0
Hexanchus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Centrophoroides	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Squalus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Somniosinae (subfamily)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Etmopterinae (subfamily)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Squatina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Synechodus	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heterodontus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Chiloscyllium	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0
Brachaelurus	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cretorectolobus	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	1
Eucrossorhinus	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Cantioscyllium	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Ginglymostoma	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Nebrius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Plicatoscyllium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
?Rhincodontidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Pararhindodon	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0
Carcharias	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	1	1	0	1	1

Appendix A: Table of data for Hierarchical Cluster Analysis for genus level analysis (0-absent, 1-present).

	MT_Judith_River_Formation	MT_Hell_Creek_Formation	WY_"Mesaverde_Formation"	WY_Lance_Formation	ND_Hell_Creek_Formation	SD_Carlile_Shale	SD_Greenhorn_Formation	CO_Greenhorn_Limestone	AB_Judith_River_Formation	AB_Dinosaur_Park_Formation	SK_Judith_River_Formation	SK_Niobrara_Formation	KS_Carlile_Shale_Formation	KS_Niobrara_Chalk	AZ_Greenhorn_Cyclothem	TX_Woodbine_Group	TX_Eagle_Ford_Group	TX_Austin_Group	TX_Taylor_Group	TX_Navarro_Group
Cenocarcharias	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Hypotodus	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Johnlongia	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Odontaspis	1	0	1	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1
Pseudodontaspis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synodontaspis	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Anomotodon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Scapanorhynchus	0	0	1	0	0	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1
Scapanorhynchus sp. or Carcharias sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Archaeolamna	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Cretodus	0	0	0	0	0	1	1	1	0	0	0	1	1	0	1	1	1	1	0	0
Cretolamna	1	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1
Cretoxyrhina	0	0	0	0	0	0	1	1	0	0	0	1	0	1	1	0	1	1	0	0
Dallasiella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Leptostyrax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Paraisurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Protolamna	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Serratolamna	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Paranomotodon	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1
Microcorax	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Pseudocorax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Squalicorax	1	0	1	0	0	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1
Carcharhiniformes incertae sedis	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Appendix A continued.

	MT_Judith_River_Formation	MT_Hell_Creek_Formation	WY_"Mesaverde_Formation"	WY_Lance_Formation	ND_Hell_Creek_Formation	SD_Carlile_Shale	SD_Greenhorn_Formation	CO_Greenhorn_Limestone	AB_Judith_River_Formation	AB_Dinosaur_Park_Formation	SK_Judith River_Formation	SK_Niobrara_Formation	KS_Carlile_Shale_Formation	KS_Niobrara_Chalk	AZ_Greenhorn_Cyclothem	TX_Woodbine_Group	TX_Eagle_Ford_Group	TX_Austin_Group	TX_Taylor_Group	TX_Navarro_Group
Scyliorhinus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Scyliorhinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Galeorhinus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Palaeogaleus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Squatigaleus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Triakidae or Carcharinidae indet. gen.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Archaeotriakis	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protoplatyrhina	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
Pseudohypolophus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
Rhinobatos	0	0	1	0	0	1	1	1	0	0	0	1	0	0	1	0	1	1	1	1
Squatirhina	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Raja	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Rajidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Ankistrorhynchus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
?Ganopristinae	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hamrabatis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ischyrhiza	1	1	1	1	1	1	0	0	0	1	0	0	0	0	1	0	1	1	1	1
Kiestus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Onchopristis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
Onchosaurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ptychotrygon	1	0	1	0	1	1	0	1	0	1	0	0	0	0	1	1	1	1	1	1
Schizorhiza	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sclerorhynchus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1

Appendix A continued.

	Texatrygon	Sclerorhynchidae indet.	Peyeria	Coupatezia	Dasyatis	?Dasyatidae	Myledaphus	Texabatis	Family - ?Ganopristinae	Brachyrhizodus	Enantiobatis	Myliobatidae	Rhombodus	Cretomanta	Ewingia
TX_Navarro_Group	0	0	0	1	1	0	0	1	0	0	0	0	1	0	1
TX_Taylor_Group	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0
TX_Austin_Group	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0
TX_Eagle_Ford_Group	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0
TX_Woodbine_Group	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0
AZ_Greenhorn_Cyclothem	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KS_Niobrara_Chalk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KS_Carlile_Shale_Formation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SK_Niobrara_Formation	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SK_Judith_River_Formation	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
AB_Dinosaur_Park_Formation	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
AB_Judith_River_Formation	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
CO_Greenhorn_Limestone	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
SD_Greenhorn_Formation	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SD_Carlile_Shale	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
ND_Hell_Creek_Formation	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
WY_Lance_Formation	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
WY_"Mesaverde_Formation"	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MT_Hell_Creek_Formation	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MT_Judith_River_Formation	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0

Appendix A continued.

APPENDIX B

WESTERN INTERIOR SEAWAY SPECIES DATA FOR HIERARCHICAL CLUSTER ANALYSIS

	MT_Judith_River_Formation	MT_Hell_Creek_Formation	WY_"Mesaverde_Formation"	WY_Lance_Formation	ND_Hell_Creek_Formation	SD_Carlile_Shale	SD_Greenhorn_Formation	CO_Greenhorn_Limestone	AB_Judith_River_Formation	AB_Dinosaur_Park_Formation	SK_Judith_River_Formation	SK_Niobrara_Formation	KS_Carlile_Shale_Formation	KS_Niobrara_Chalk	AZ_Greenhorn_Cyclothem	TX_Woodbine_Group	TX_Eagle_Ford_Group	TX_Austin_Group	TX_Taylor_Group	TX_Navarro_Group
Hybodus_montanensis	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Hybodus_storeri	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybodus_wyomingensis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybodus_sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
Hybodus_sp._1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Hybodus_sp._2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Hybodus_sp._3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Lissodus_aff._babulskii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Lissodus_griffisi	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lissodus_selachos	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Lissodus_sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Lissodus_spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Polyacrodus_illingsworthi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Ptychodus_anonymus	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	1	0	0	0
Ptychodus_connellyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Ptychodus_decurrens	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	1	1	0	0
Ptychodus_latissimus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
Ptychodus_mammilaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0
Ptychodus_mortoni	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0
Ptychodus_occidentalis	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0
Ptychodus_polygyrus	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Ptychodus_rugosus	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0
Ptychodus_whipplei	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0	1	1	0	0

Appendix B: Table of data for Hierarchical Cluster Analysis for species level analysis (0-absent, 1-present).

	MT_Judith_River_Formation	MT_Hell_Creek_Formation	WY_"Mesaverde_Formation"	WY_Lance_Formation	ND_Hell_Creek_Formation	SD_Carlile_Shale	SD_Greenhorn_Formation	CO_Greenhorn_Limestone	AB_Judith_River_Formation	AB_Dinosaur_Park_Formation	SK_Judith_River_Formation	SK_Niobrara_Formation	KS_Carlile_Shale_Formation	KS_Niobrara_Chalk	AZ_Greenhorn_Cyclothem	TX_Woodbine_Group	TX_Eagle_Ford_Group	TX_Austin_Group	TX_Taylor_Group	TX_Navarro_Group
Ptychodus sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
Hexanchus microdon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Hexanchus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Centrophoroides worlandensis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Squalus huntensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Squalus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Somniosinae (subfamily)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Etmopterinae (subfamily)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Squatina hassei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Synechodus andersoni	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synechodus illingworthi?	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synechodus striatus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synechodus turneri	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synechodus sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heterodontus cf. canaliculatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Heterodontus granti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Heterodontus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Chiloscyllium greeni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0
Chiloscyllium missouriensis	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiloscyllium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Brachaelurus bighornensis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachaelurus greeni	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cretorectolobus olsoni	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1

Appendix B continued.

	MT_Judith_River_Formation	MT_Hell_Creek_Formation	WY_"Mesaverde_Formation"	WY_Lance_Formation	ND_Hell_Creek_Formation	SD_Carlile_Shale	SD_Greenhorn_Formation	CO_Greenhorn_Limestone	AB_Judith_River_Formation	AB_Dinosaur_Park_Formation	SK_Judith_River_Formation	SK_Niobrara_Formation	KS_Carlile_Shale_Formation	KS_Niobrara_Chalk	AZ_Greenhorn_Cyclothem	TX_Woodbine_Group	TX_Eagle_Ford_Group	TX_Austin_Group	TX_Taylor_Group	TX_Navarro_Group
Cretorectolobus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Eucrossorhinus microcuspidatus	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Cantioscyllium decipiens	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Cantioscyllium meyeri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Cantioscyllium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ginglymostoma globidens	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ginglymostoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Nebrius sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Plicatoscyllium antiquum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Plicatoscyllium derameei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
?Rhincodontidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Pararhincodon groessenssi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Pararhincodon aff. lehmani	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
cf. Pararhincodon sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Carcharias amonensis	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0
Carcharias heathi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Carcharias holmdelensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Carcharias cf. samhammeri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Carcharias saskatchewanensis	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Carcharias steineri	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Carcharias tenuiplicatus	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0
Carcharias sp.	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Carcharias sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Appendix B continued.

	MT_Judith_River_Formation	MT_Hell_Creek_Formation	WY_"Mesaverde_Formation"	WY_Lance_Formation	ND_Hell_Creek_Formation	SD_Carlile_Shale	SD_Greenhorn_Formation	CO_Greenhorn_Limestone	AB_Judith_River_Formation	AB_Dinosaur_Park_Formation	SK_Judith_River_Formation	SK_Niobrara_Formation	KS_Carlile_Shale_Formation	KS_Niobrara_Chalk	AZ_Greenhorn_Cyclothem	TX_Woodbine_Group	TX_Eagle_Ford_Group	TX_Austin_Group	TX_Taylor_Group	TX_Navarro_Group
Carcharias sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Carcharias sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Cenocarcharias tenuiplicatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Hypotodus grandis	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypotodus spp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Johnlongia parvidens	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
cf. Johnlongia sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Odontaspis aculeatus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Odontaspis amonensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Odontaspis cheathami	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odontaspis sanguinei	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odontaspis saskatchewanensis	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Odontaspis steineri	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odontaspis tenuiplicatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Odontaspis sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudodontaspis herbsti	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synodontaspis lilliae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Anomotodon toddi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Scapanorhynchus aff. praeraphiodon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Scapanorhynchus raphiodon	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	1	1	0	0
Scapanorhynchus texanus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Scapanorhynchus sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1
Scapanorhynchus sp. or Carcharias sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Appendix B continued.

	MT_Judith_River_Formation	MT_Hell_Creek_Formation	WY_"Mesaverde_Formation"	WY_Lance_Formation	ND_Hell_Creek_Formation	SD_Carlile_Shale	SD_Greenhorn_Formation	CO_Greenhorn_Limestone	AB_Judith_River_Formation	AB_Dinosaur_Park_Formation	SK_Judith_River_Formation	SK_Niobrara_Formation	KS_Carlile_Shale_Formation	KS_Niobrara_Chalk	AZ_Greenhorn_Cyclothem	TX_Woodbine_Group	TX_Eagle_Ford_Group	TX_Austin_Group	TX_Taylor_Group	TX_Navarro_Group
Archaeolamna_kopingensis	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Cretodus_semiplicatus	0	0	0	0	0	1	1	1	0	0	0	0	1	0	1	1	1	1	0	0
Cretodus_sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Cretolamna_appendiculata	1	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1
Cretolamna_maroccana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cretolamna_woodwardi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Cretolamna_sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cretoxyrhina_mantelli	0	0	0	0	0	0	1	1	0	0	0	1	0	1	1	0	1	1	0	0
Dallasiella_willistoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Leptostyrax_macrorhiza	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
cf._Leptostyrax_sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Paraisurus_compressus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Protolamna_carteri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Protolamna_compressidens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Protolamna_sokolovi	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Serratolamna_serrata	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Paranomotodon_sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1
Microcorax_crassus	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Pseudocorax_granti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Squalicorax_baharijensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Squalicorax_curvatus	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0
Squalicorax_falcatus	0	0	0	0	0	1	1	1	0	0	0	1	1	1	1	1	1	1	0	0
Squalicorax_kaupi	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Appendix B continued.

	TX_Navarro_Group	TX_Taylor_Group	TX_Austin_Group	TX_Eagle_Ford_Group	TX_Woodbine_Group	AZ_Greenhorn_Cyclothem	KS_Niobrara_Chalk	KS_Carlile_Shale_Formation	SK_Niobrara_Formation	SK_Judith_River_Formation	AB_Dinosaur_Park_Formation	AB_Judith_River_Formation	CO_Greenhorn_Limestone	SD_Greenhorn_Formation	SD_Carlile_Shale	ND_Hell_Creek_Formation	WY_Lance_Formation	WY_"Mesaverde_Formation"	MT_Hell_Creek_Formation	MT_Judith_River_Formation
Squalicorax pristodontus	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Squalicorax volgensis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Squalicorax sp.	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Squalicorax sp. 1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Squalicorax sp. 2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carcharhiniformes incertae sedis	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Scyliorhinus arlingtonensis	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scyliorhinus ivagrantae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scyliorhinus taylorensis	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scyliorhinus tensleepensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Scyliorhinidae	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galeorhinus aff. girardoti	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galeorhinus sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Palaeogaleus navarroensis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Palaeogaleus sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Squatigaleus sulphurensis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Triakidae or Carcharinidae indet. gen.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Archaeotriakis ornatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Archaeotriakis rochelleae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Protoplatyrhina hopii	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protoplatyrhina renae	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1
Pseudohypolophus mcnultyi	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
?Pseudohypolophus sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Appendix B continued.

	MT_Judith_River_Formation	MT_Hell_Creek_Formation	WY_"Mesaverde_Formation"	WY_Lance_Formation	ND_Hell_Creek_Formation	SD_Carlile_Shale	SD_Greenhorn_Formation	CO_Greenhorn_Limestone	AB_Judith_River_Formation	AB_Dinosaur_Park_Formation	SK_Judith_River_Formation	SK_Niobrara_Formation	KS_Carlile_Shale_Formation	KS_Niobrara_Chalk	AZ_Greenhorn_Cyclothem	TX_Woodbine_Group	TX_Eagle_Ford_Group	TX_Austin_Group	TX_Taylor_Group	TX_Navarro_Group
Rhinobatos casieri	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Rhinobatos craddocki	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Rhinobatos incertus	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0
?Rhinobatos incertus sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhinobatos kiestensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Rhinobatos ladoniaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Rhinobatos lobatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Rhinobatos uvulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Rhinobatos sp.	0	0	0	0	0	1	0	1	0	0	0	1	0	0	1	0	1	1	0	0
Squatirhina americana	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Squatirhina roessingi	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Squatirhina sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
?Squatirhina sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Raja farishi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Rajidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Ankistrorhynchus washakiensis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
?Ganopristinae	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hamrabatis weltoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ischyrhiza avonicola	1	1	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1
Ischyrhiza basinensis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ischyrhiza mira	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1
Ischyrhiza monasterica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ischyrhiza schneideri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0

Appendix B continued.

	MT_Judith_River_Formation	MT_Hell_Creek_Formation	WY_"Mesaverde_Formation"	WY_Lance_Formation	ND_Hell_Creek_Formation	SD_Carlile_Shale	SD_Greenhorn_Formation	CO_Greenhorn_Limestone	AB_Judith_River_Formation	AB_Dinosaur_Park_Formation	SK_Judith_River_Formation	SK_Niobrara_Formation	KS_Carlile_Shale_Formation	KS_Niobrara_Chalk	AZ_Greenhorn_Cyclothem	TX_Woodbine_Group	TX_Eagle_Ford_Group	TX_Austin_Group	TX_Taylor_Group	TX_Navarro_Group
Ischyrhiza texana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Ischyrhiza sp.	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kiestus texanus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Onchopristis dunklei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
Onchosaurus pharo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ptychotrygon agujaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ptychotrygon blainensis	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Ptychotrygon boothi	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptychotrygon ellae	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptychotrygon greybullensis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptychotrygon hooveri	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Ptychotrygon ledouxi	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptychotrygon rubyae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ptychotrygon slaughteri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ptychotrygon texana	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ptychotrygon triangularis	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Ptychotrygon vermiculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ptychotrygon winni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ptychotrygon sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Schizorhiza cf. weileri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sclerorhynchus fanninensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Sclerorhynchus pettersi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sclerorhynchus priscus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0

Appendix B continued.

	MT_Judith_River_Formation	MT_Hell_Creek_Formation	WY_"Mesaverde_Formation"	WY_Lance_Formation	ND_Hell_Creek_Formation	SD_Carlile_Shale	SD_Greenhorn_Formation	CO_Greenhorn_Limestone	AB_Judith_River_Formation	AB_Dinosaur_Park_Formation	SK_Judith_River_Formation	SK_Niobrara_Formation	KS_Carlile_Shale_Formation	KS_Niobrara_Chalk	AZ_Greenhorn_Cyclothem	TX_Woodbine_Group	TX_Eagle_Ford_Group	TX_Austin_Group	TX_Taylor_Group	TX_Navarro_Group
Sclerorhynchus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Sclerorhynchus sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Sclerorhynchus sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Texatrygon copei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Texatrygon hooveri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Sclerorhynchidae indet.	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Peyeria sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coupatezia turneri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Dasyatis commercensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Dasyatis spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
?Dasyatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Myledaphus bipartitus	1	1	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
Texabatis corrugata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Family - ?Ganopristinae	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachyrhizodus wichitaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Enantiobatis tarrantensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Myliobatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Rhombodus binkhorsti	0	0	0	0	0	0	0	0	0	0.	0	0	0	0	0	0	0	0	0	1
Rhombodus ? sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cretomanta canadensis	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	1	1	0	0
Ewingia problematica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Appendix B continued.

APPENDIX C

WESTERN INTERIOR SEAWAY GENERA DATA FOR PARSIMONY ANALYSIS OF ENDEMICITY

Genus	Hypothetical Ancestral Locality	MT Judith River Formation	WY "Mesaverde Formation"	ND Hell Creek Formation	SD Carlile Shale	SD Greenhorn Formation	CO Greenhorn Limestone	AB Dinosaur Park Formation	AZ Greenhorn Cyclothem	TX Woodbine Group	TX Eagle Ford Group	TX Austin Group	TX Taylor Group	TX Navarro Group
Cretolamna	0	1	0	1	1	1	1	0	1	1	1	1	1	1
Cretodus	0	0	0	0	1	1	1	0	1	1	1	1	0	0
Archaeolamna	0	1	1	0	0	0	1	1	0	0	0	0	0	0
Scapanorhynchus	0	0	1	0	1	1	0	0	1	1	1	1	1	1
Odontaspis	0	1	1	1	0	0	0	1	0	1	0	0	0	1
Johnlongia	0	0	0	0	1	1	1	0	0	0	0	0	0	0
Hypotodus	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Carcharias	0	0	0	1	0	1	1	1	0	1	1	0	1	1
Pararhindodon	0	0	0	0	0	0	1	0	0	1	0	0	1	0
Plicatoscyllium	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Ginglymostoma	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Cantioscyllium	0	0	0	0	1	0	0	0	0	1	1	1	1	1
Eucrossorhinus	0	1	1	0	0	0	0	1	0	0	0	0	0	0
Cretorectolobus	0	1	1	0	0	0	0	1	0	1	1	0	0	1
Chiloscyllium	0	1	1	0	0	0	0	0	1	1	1	1	1	0
Heterodontus	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Synechodus	0	1	1	0	1	0	0	0	0	0	0	0	0	0
Squatina	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Squalus	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Hexanchus	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Ptychodus	0	0	0	0	1	1	1	0	1	1	1	1	1	0
Lissodus	0	0	1	0	0	0	0	0	0	1	0	0	1	1
Hybodus	0	1	1	0	0	0	0	1	1	1	1	1	0	0

Appendix C: Table of data for Parsimony Analysis of Endemicity (PAE) for genus level analysis (0-absent, 1-present).

Appendix C continued.

	Cretoxyrhina	Dallasiella	Leptostyrax	Protolamna	Serratolamna	Paranomotodon	Microcorax	Pseudocorax	Squalicorax	Scyliorhinus	Scyliorhinidae	Galeorhinus	Palaeogaleus	Archaeotriakis	Protoplatyrhina	Pseudohypolophus	Rhinobatos	Squatirhina	Rajidae	Ischyrhiza	Kiestus	Onchopristis	Ptychotrygon
Hypothetical Ancestral Locality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT Judith River Formation	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	1	0	1	0	0	1
WY "Mesaverde Formation"	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	1	1	0	1	0	0	1
ND Hell Creek Formation	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	1
SD Carlile Shale	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1
SD Greenhorn Formation	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
CO Greenhorn Limestone	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1
AB Dinosaur Park Formation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1
AZ Greenhorn Cyclothem	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	1	0	1	1
TX Woodbine Group	0	0	1	1	0	0	1	0	1	1	1	0	0	0	0	1	0	1	0	0	0	1	1
TX Eagle Ford Group	1	1	0	1	0	0	0	1	1	0	1	0	0	0	0	1	1	0	0	1	1	1	1
TX Austin Group	1	1	0	1	0	1	0	1	1	0	1	0	0	0	0	0	1	0	0	1	1	1	1
TX Taylor Group	0	0	0	0	1	1	0	1	1	1	1	1	1	0	0	0	1	0	1	1	0	0	1
TX Navarro Group	0	0	0	0	1	1	0	1	1	1	1	1	1	0	1	0	1	0	1	1	0	0	1

	Sclerorhynchus	Texatrygon	Sclerorhynchidae_indet.	Dasyatis	Myledaphus	Cretomanta
Hypothetical Ancestral Locality	0	0	0	0	0	0
MT Judith River Formation	0	0	1	0	1	0
WY "Mesaverde Formation"	0	0	0	0	1	0
ND Hell Creek Formation	0	0	0	0	1	0
SD Carlile Shale	0	0	0	0	0	0
SD Greenhorn Formation	0	0	0	0	0	1
CO Greenhorn Limestone	0	0	1	0	0	1
AB Dinosaur Park Formation	0	0	0	0	1	0
AZ Greenhorn Cyclothem	0	0	0	0	0	0
TX Woodbine Group	0	0	0	1	0	0
TX Eagle Ford Group	1	1	0	1	0	1
TX Austin Group	1	1	0	1	0	1
TX Taylor Group	1	1	0	1	0	0
TX Navarro Group	1	0	0	1	0	0

Appendix C continued.

APPENDIX D

WESTERN INTERIOR SEAWAY SPECIES DATA FOR PARSIMONY ANALYSIS OF ENDEMICITY

Species	Hypothetical Ancestral Locality	MT Judith River Formation	WY "Mesaverde Formation"	SD Carlile Shale	SD Greenhorn Formation	CO Greenhorn Limestone	AZ Greenhorn Cyclothem	TX Woodbine Group	TX Eagle Ford Group	TX Austin Group	TX Taylor Group	TX Navarro Group
Cretorectolobus_sp.	0	0	0	0	0	0	0	1	1	0	0	0
Cretorectolobus_olsoni	0	1	1	0	0	0	0	0	0	0	0	1
Chiloscyllium_missouriensis	0	1	1	0	0	0	0	0	0	0	0	0
Chiloscyllium_greeni	0	0	0	0	0	0	1	1	1	1	1	0
Heterodontus_sp.	0	0	0	0	0	0	0	0	1	1	0	0
Heterodontus_cf._canaliculatus	0	0	0	0	0	0	0	0	0	1	1	0
Squatina_hassei	0	0	0	0	0	0	0	0	0	0	1	1
Squalus_sp.	0	0	0	0	0	0	0	0	0	0	1	1
Hexanchus_microdon	0	0	0	0	0	0	0	0	0	0	1	1
Ptychodus_sp.	0	0	0	0	1	0	0	0	0	1	0	0
Ptychodus_whipplei	0	0	0	1	1	0	1	0	1	1	0	0
Ptychodus_rugosus	0	0	0	0	0	0	0	0	1	1	0	0
Ptychodus_polygyrus	0	0	0	1	0	0	0	0	1	0	0	0
Ptychodus_occidentalis	0	0	0	0	1	1	0	0	1	0	0	0
Ptychodus_mortoni	0	0	0	0	0	0	0	0	1	1	0	0
Ptychodus_mammilaris	0	0	0	0	0	0	1	0	1	1	0	0
Ptychodus_latissimus	0	0	0	0	0	0	0	0	1	1	1	0
Ptychodus_decurrens	0	0	0	0	1	1	1	1	1	1	0	0
Ptychodus_anonymus	0	0	0	1	1	1	0	0	1	0	0	0
Lissodus_spp.	0	0	0	0	0	0	0	1	0	0	1	1
Lissodus_selachos	0	0	0	0	0	0	0	0	0	0	1	0
Hybodus_sp.	0	0	0	0	0	0	1	1	1	1	0	0
Hybodus_montanensis	0	1	1	0	0	0	0	0	0	0	0	0

Appendix D: Table of data for Parsimony Analysis of Endemicity (PAE) for species level analysis (0-absent, 1-present).

	Hypothetical Ancestral Locality	MT Judith River Formation	WY "Mesaverde Formation"	SD Carlile Shale	SD Greenhorn Formation	CO Greenhorn Limestone	AZ Greenhorn Cyclothem	TX Woodbine Group	TX Eagle Ford Group	TX Austin Group	TX Taylor Group	TX Navarro Group
Serratolamma_serrata	0	0	0	0	0	0	0	0	0	0	1	1
Protolamna_sokolovi	0	1	0	0	0	0	0	1	0	0	0	0
Protolamna_compressidens	0	0	0	0	0	0	0	0	1	1	0	0
Dallasiella_willistoni	0	0	0	0	0	0	0	0	1	1	0	0
Cretoxyrhina_mantelli	0	0	0	0	1	1	1	0	1	1	0	0
Cretolamna_woodwardi	0	0	0	0	0	0	1	0	1	0	0	0
Cretolamna_appendiculata	0	1	0	1	1	1	1	1	1	1	1	1
Cretodus_semiplicatus	0	0	0	1	1	1	1	1	1	1	0	0
Archaeolamna_kopingensis	0	1	1	0	0	1	0	0	0	0	0	0
Scapanorhynchus_sp.	0	0	0	0	0	0	0	0	0	0	0	1
Scapanorhynchus_texanus	0	0	1	0	0	0	0	0	0	0	1	1
Scapanorhynchus_raphiodon	0	0	0	1	1	0	1	0	1	1	0	0
Odontaspis_aculeatus	0	0	0	0	0	0	0	0	0	0	0	1
Johnlongia_parvidens	0	0	0	1	1	1	0	0	0	0	0	0
Carcharias_sp._B	0	0	0	0	0	0	0	0	0	0	1	1
Carcharias_sp.	0	0	0	0	1	0	0	0	0	0	0	0
Carcharias_tenuiplicatus	0	0	0	0	1	1	0	1	0	0	0	0
Carcharias_saskatchewanensis	0	0	0	0	1	1	0	0	0	0	0	0
Carcharias_amonensis	0	0	0	0	1	0	0	1	1	0	0	0
Plicatoscyllium_derameei	0	0	0	0	0	0	0	0	0	0	1	1
Cantioscyllium_meyeri	0	0	0	0	0	0	0	0	0	0	1	1
Cantioscyllium_decipiens	0	0	0	1	0	0	0	1	1	1	0	0
Eucrossorhinus_microcuspidatus	0	1	1	0	0	0	0	0	0	0	0	0

Appendix D continued.

	Paranomotodon_sp.	Microcorax_crassus	Pseudocorax_granti	Squalicorax_curvatus	Squalicorax_falcatus	Squalicorax_kaupi	Squalicorax_pristodontus	Squalicorax_sp.	Squalicorax_sp._1	Squalicorax_sp._2	Scyliorhinus_arlingtonensis	Scyliorhinidae	Galeorhinus_sp.	Palaeogaleus_sp.	Archaeotriakis_rochelleae	Protoplatyrhina_renae	Pseudohypolophus_mcnultyi	?Pseudohypolophus_sp.	Rhinobatos_casieri	Rhinobatos_incertus	Rhinobatos_kiestensis	Rhinobatos_lobatus	Rhinobatos_sp.
Hypothetical Ancestral Locality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT Judith River Formation	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
WY "Mesaverde Formation"	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
SD Carlile Shale	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SD Greenhorn Formation	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
CO Greenhorn Limestone	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
AZ Greenhorn Cyclothem	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TX Woodbine Group	0	1	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0
TX Eagle Ford Group	0	0	1	1	1	0	0	1	1	1	0	1	0	0	0	0	1	0	0	1	1	1	1
TX Austin Group	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	1	1	1
TX Taylor Group	1	0	1	0	0	1	1	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0
TX Navarro Group	1	0	1	0	0	1	1	0	0	0	1	1	1	1	0	1	0	0	0	0	0	0	0

Appendix D continued.

	Squatirhina_sp.	Rajidae	Ischyrhiza_avonicola	Ischyrhiza_mira	Ischyrhiza_schneideri	Ischyrhiza_texana	Ischyrhiza_sp.	Kiestus_texanus	Onchopristis_dunklei	Ptychotrygon_blainensis	Ptychotrygon_hooveri	Ptychotrygon_texana	Ptychotrygon_triangularis	Sclerorhynchus_priscus	Sclerorhynchus_sp.	Sclerorhynchus_sp._2	Texatrygon_hooveri	Sclerorhynchidae_indet.	Dasyatis_spp.	Myledaphus_bipartitus	Cretomanta_canadensis
Hypothetical Ancestral Locality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT Judith River Formation	1	0	1	1	0	0	1	0	0	1	1	0	1	0	0	0	0	1	0	1	0
WY "Mesaverde Formation"	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SD Carlile Shale	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SD Greenhorn Formation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
CO Greenhorn Limestone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
AZ Greenhorn Cyclothem	0	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
TX Woodbine Group	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0
TX Eagle Ford Group	0	0	0	0	1	1	0	1	1	0	1	0	1	1	0	1	1	0	1	0	1
TX Austin Group	0	0	0	0	1	1	0	1	1	0	1	0	1	1	1	1	1	0	1	0	1
TX Taylor Group	0	1	1	1	0	1	0	0	0	1	0	0	1	0	1	0	0	0	1	0	0
TX Navarro Group	0	1	1	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0

Appendix D continued.

APPENDIX E

PAST RESULTS OF X^2-TEST OF OBSERVED VERSUS EXPECTED OF PRELIMINARY CHARACTERIZATION SCALE AND PRELIMINARY TAPHONOMIC CHARACTERIZATION ADDENDUM

A	o	e
Pristine_(patchy_coloration)	7	6.75
Root_minimally_abraded_crown_patchy_coloration	0	2.25
Pristine_(crown_tip_broken)	0	0.375
Root_abraded_w/_coloration	1	0.375
Broken	4	4.875
Broken_patchy_coloration	6	3.375
	chi	0.3186
	df	5

From PAST	
N1	18
N2	18
df	5
chisq	5.8746
p(same)	0.31861
Monte Carlo p(same)	0.2743

L	o	e
Pristine_(patchy_coloration)	5	4.125
Root_minimally_abraded_crown_patchy_coloration	4	1.375
Pristine_(crown_tip_broken)	0	0.229
Root_abraded_w/_coloration	0	0.229
Broken	0	2.979
Broken_patchy_coloration	2	2.063
	chi	0.1245
	df	5

From PAST	
N1	11
N2	11
df	5
chisq	8.6359
p(same)	0.1245
Monte Carlo p(same)	0.1065

P	o	e
Pristine_(patchy_coloration)	6	7.125
Root_minimally_abraded_crown_patchy_coloration	2	2.375
Pristine_(crown_tip_broken)	1	0.396
Root_abraded_w/_coloration	0	0.396
Broken	9	5.146
Broken_patchy_coloration	1	3.563

From PAST	
N1	19
N2	19
df	5
chisq	6.2841
p(same)	0.27954
Monte Carlo p(same)	0.2575

Appendix E: PAST results of X^2-test of Preliminary Characterization Scale (Observed versus Expected).

Woodhawk (WH)

error in CHSONE - bad expected number

A	o	e	From PAST	
Pristine	**0**	**0**	N1	22
Almost_pristine_may_have_patchy_coloration	8	10.127	N2	22
Pristine_but_crown_tip_broken	4	2.095	df	4
Root_minimally_abraded_may_have_patchy_coloration	3	1.397	chisq	5.6254
Root_abraded_may_have_patchy_coloration	2	1.048	p(same)	0.2289
Broken_may_have_patchy_coloration	5	7.333	Monte Carlo p(same)	0.2121
	chi	0.2289		
	df	4		

L	o	e	From PAST	
Pristine	**0**	**0**	N1	17
Almost_pristine_may_have_patchy_coloration	10	7.825	N2	17
Pristine_but_crown_tip_broken	0	1.619	df	4
Root_minimally_abraded_may_have_patchy_coloration	0	1.079	chisq	3.3667
Root_abraded_may_have_patchy_coloration	1	0.81	p(same)	0.4984
Broken_may_have_patchy_coloration	6	5.667	Monte Carlo p(same)	0.4747
	chi	0.4984		
	df	4		

P	o	e	From PAST	
Pristine	**0**	**0**	N1	24
Almost_pristine_may_have_patchy_coloration	11	11.048	N2	24
Pristine_but_crown_tip_broken	2	2.286	df	4
Root_minimally_abraded_may_have_patchy_coloration	1	1.524	chisq	1.8592
Root_abraded_may_have_patchy_coloration	0	1.143	p(same)	0.7616
Broken_may_have_patchy_coloration	10	8	Monte Carlo p(same)	0.771
	chi	0.7616		
	df	4		

Appendix E continued: PAST results of X^2-test of Preliminary Taphonomic Characterization Addendum (Observed versus Expected) for WH.

Power Plant Ferry (PPF)
error in CHSONE - bad expected number

A	o	e	From PAST	
Pristine	5	3.238	N1	17
Almost_pristine_may_have_patchy_coloration	1	0.405	N2	17
Pristine_but_crown_tip_broken	1	0.81	df	5
Root_minimally_abraded_may_have_patchy_coloration	0	0.81	chisq	3.073
Root_abraded_may_have_patchy_coloration	1	0.81	p(same)	0.689
Broken_may_have_patchy_coloration	9	10.929	Monte Carlo p(same)	0.666
	chi	0.6888		
	df	5		

L	o	e	From PAST	
Pristine	0	3.619	N1	19
Almost_pristine_may_have_patchy_coloration	0	0.452	N2	19
Pristine_but_crown_tip_broken	1	0.905	df	5
Root_minimally_abraded_may_have_patchy_coloration	2	0.905	chisq	6.051
Root_abraded_may_have_patchy_coloration	1	0.905	p(same)	0.301
Broken_may_have_patchy_coloration	15	12.214	Monte Carlo p(same)	0.281
	chi	0.3013		
	df	5		

P	o	e	From PAST	
Pristine	3	1.143	N1	6
Almost_pristine_may_have_patchy_coloration	0	0.143	N2	6
Pristine_but_crown_tip_broken	0	0.286	df	5
Root_minimally_abraded_may_have_patchy_coloration	0	0.286	chisq	4.208
Root_abraded_may_have_patchy_coloration	0	0.286	p(same)	0.52
Broken_may_have_patchy_coloration	3	3.857	Monte Carlo p(same)	0.355
	chi	0.5198		
	df	5		

Appendix E continued: PAST results of X^2-test of Preliminary Taphonomic Characterization Addendum (Observed versus Expected) for PPF.

APPENDIX F

PAST RESULTS OF X^2-TEST OF WH VERSUS PPF

T	WH	PPF	One constraint From PAST	
Pristine	0	8	N1	63
Almost_pristine_may_have_patchy_coloration	29	1	N2	42
Pristine_but_crown_tip_broken	6	2	df	5
Root_minimally_abraded_may_have_patchy_coloration	4	2	chisq	34.948
Root_abraded_may_have_patchy_coloration	3	2	p(same)	1.541E-06
Broken_may_have_patchy_coloration	21	27	Monte Carlo p(same)	<0.0001

A	WH	PPF		
Pristine	0	5	N1	22
Almost_pristine_may_have_patchy_coloration	8	1	N2	17
Pristine_but_crown_tip_broken	4	1	df	5
Root_minimally_abraded_may_have_patchy_coloration	3	0	chisq	16.348
Root_abraded_may_have_patchy_coloration	2	1	p(same)	0.0059169
Broken_may_have_patchy_coloration	5	9	Monte Carlo p(same)	0.0014

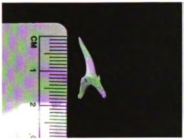
L	WH	PPF		
Pristine	0	0	N1	17
Almost_pristine_may_have_patchy_coloration	10	0	N2	19
Pristine_but_crown_tip_broken	0	1	df	4
Root_minimally_abraded_may_have_patchy_coloration	0	2	chisq	16.798
Root_abraded_may_have_patchy_coloration	1	1	p(same)	0.0021158
Broken_may_have_patchy_coloration	6	15	Monte Carlo p(same)	0.0001

P	WH	PPF		
Pristine	0	3	N1	24
Almost_pristine_may_have_patchy_coloration	11	0	N2	6
Pristine_but_crown_tip_broken	2	0	df	4
Root_minimally_abraded_may_have_patchy_coloration	1	0	chisq	15.577
Root_abraded_may_have_patchy_coloration	0	0	p(same)	0.0036427
Broken_may_have_patchy_coloration	10	3	Monte Carlo p(same)	0.0026

Appendix F: PAST results of X^2-test of WH versus PPF.

APPENDIX G

TEETH OF MODERN *CARCHARIAS TAURUS* AND *RHINOPTERA BONASUS* (TAPHONOMY SERIES)



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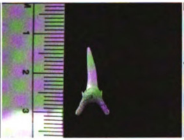

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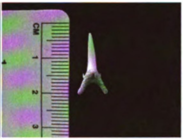

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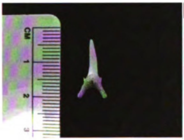

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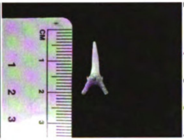

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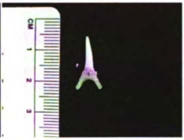

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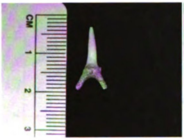

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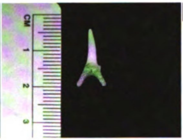

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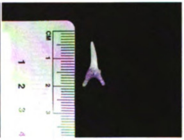

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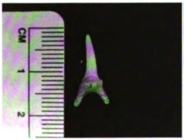

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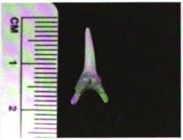

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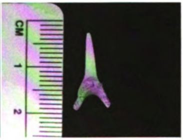
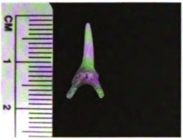


500A1ling.jpg

Appendix G: Taphonomy Series of teeth.



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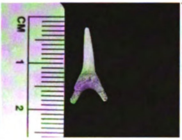

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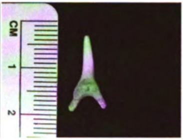

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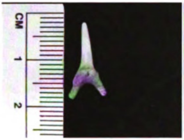

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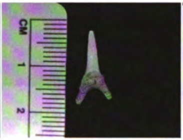

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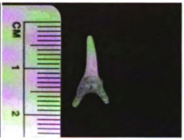

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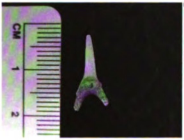

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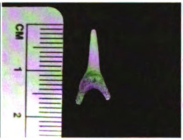

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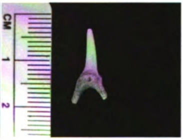

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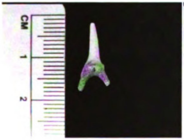

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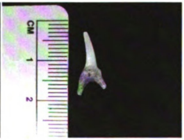

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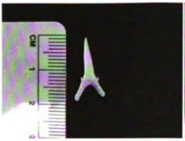

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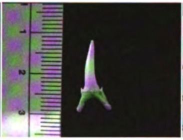

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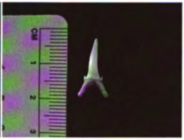

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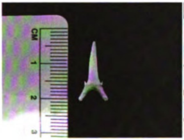

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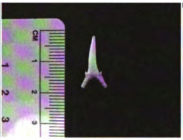

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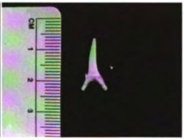

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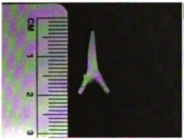

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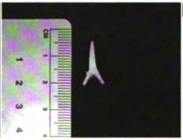

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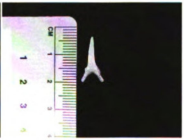

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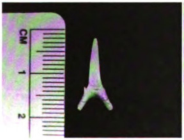

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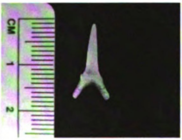

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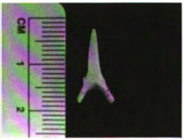

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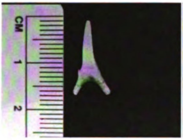

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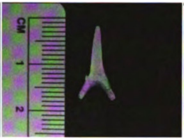

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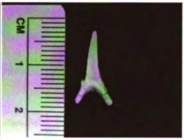

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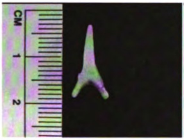

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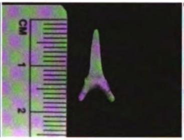

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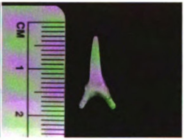

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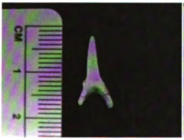

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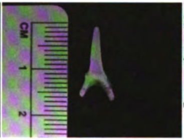

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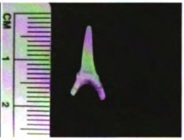

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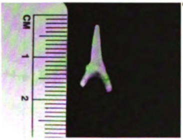

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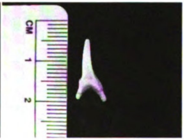

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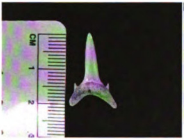

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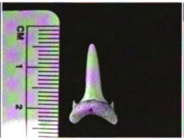

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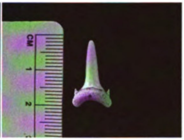

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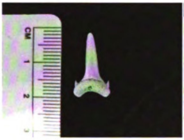

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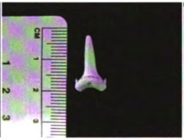

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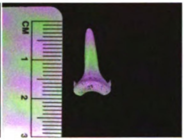

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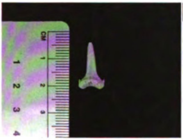

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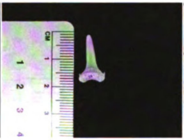

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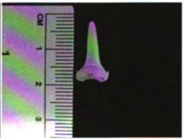

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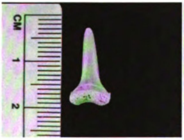

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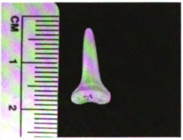

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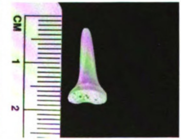

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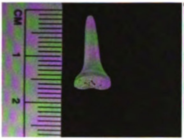

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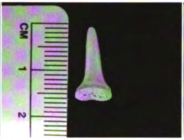

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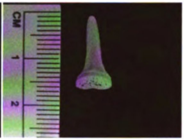

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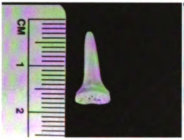

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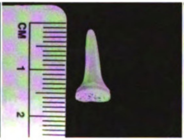

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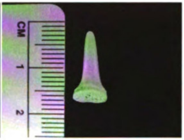

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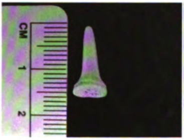

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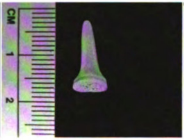

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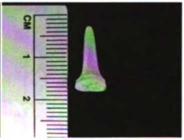

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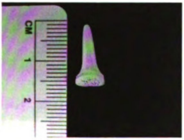

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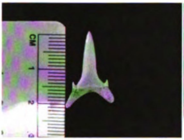

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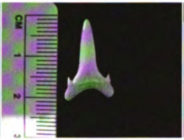

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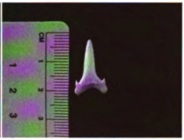

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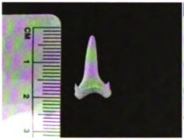

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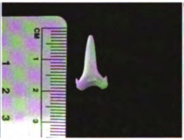

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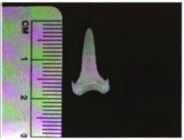

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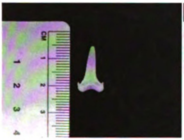

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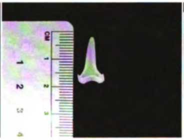

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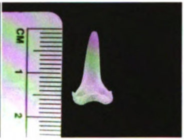

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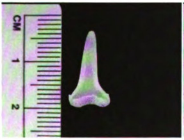

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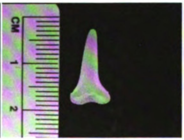

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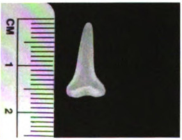

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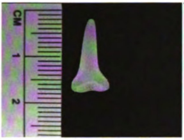

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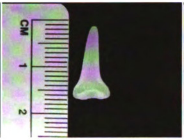

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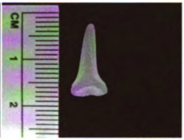

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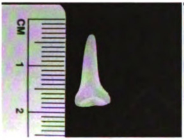

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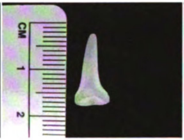

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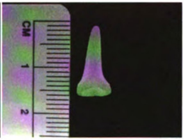

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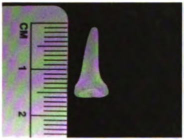

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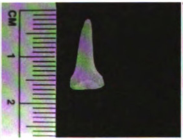

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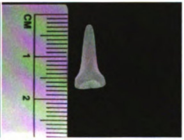

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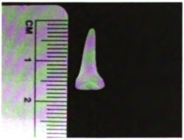

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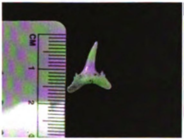

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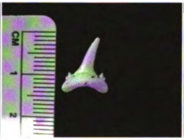

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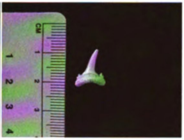

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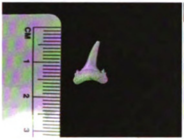

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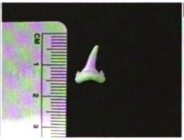

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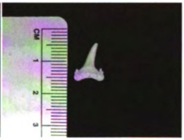

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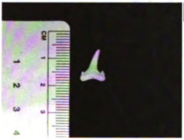

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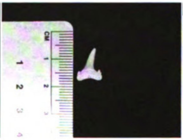

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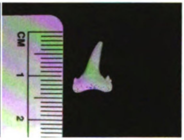

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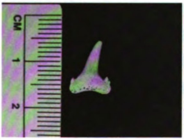

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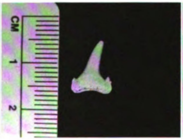

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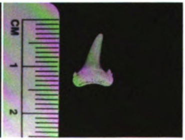

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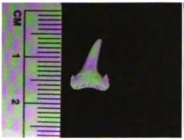

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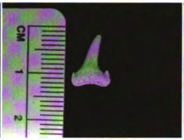

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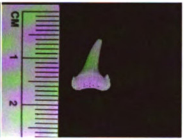

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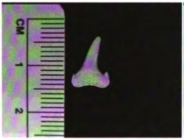

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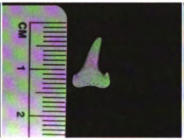

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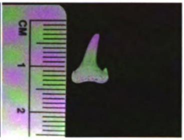

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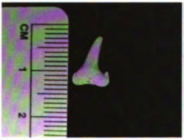

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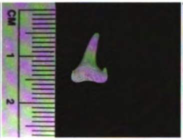

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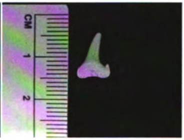

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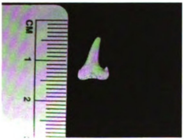

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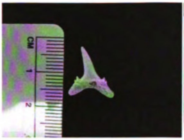

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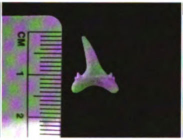

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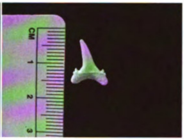

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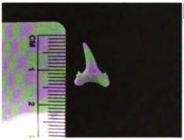

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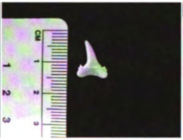

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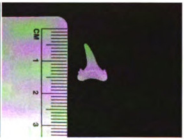

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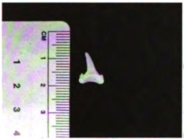

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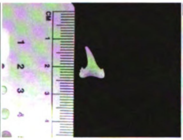

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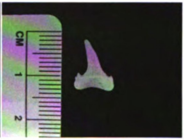

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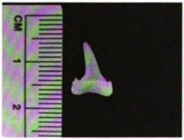

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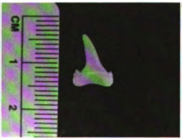

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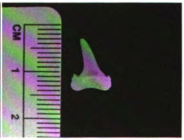

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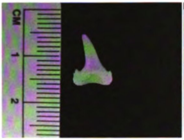

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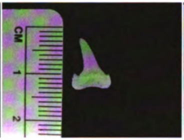

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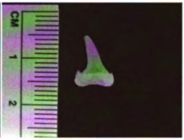

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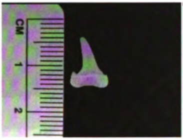

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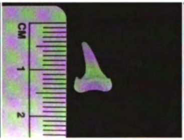

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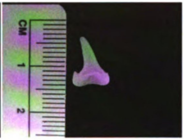

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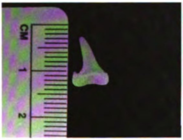

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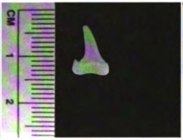

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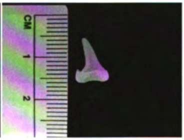

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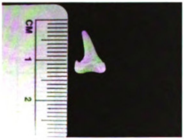

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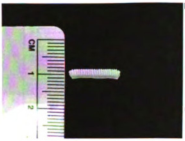

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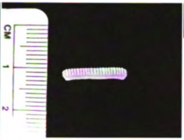

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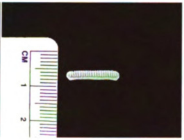

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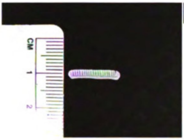

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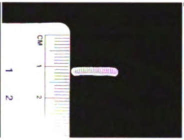

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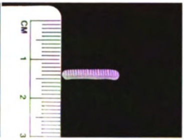

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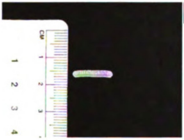

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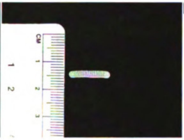

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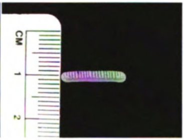

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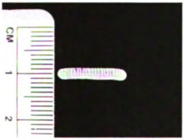

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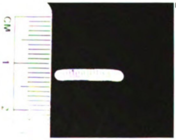

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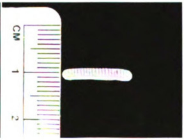

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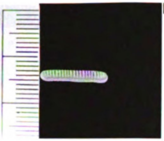

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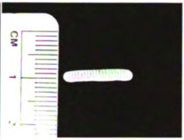

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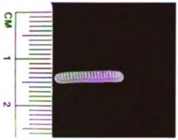

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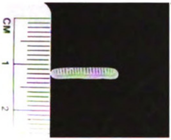

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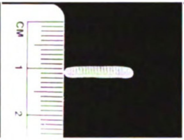

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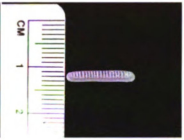

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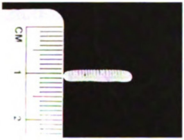

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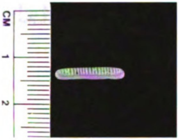

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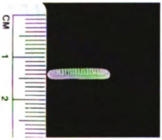

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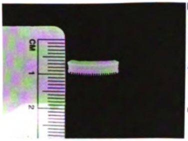

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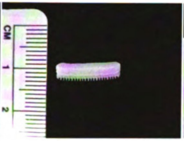

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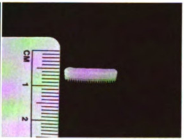

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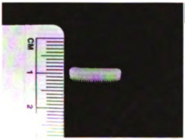

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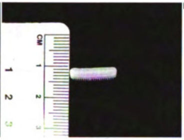

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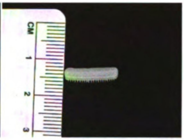

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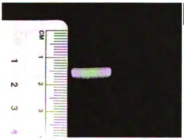

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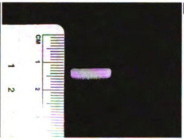

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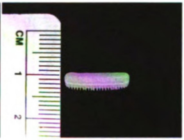

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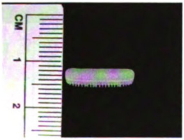

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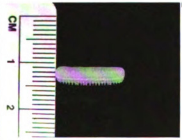

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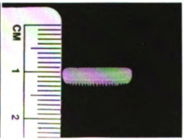

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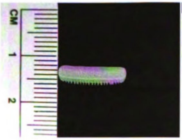

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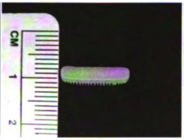

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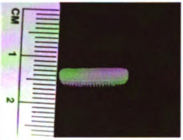

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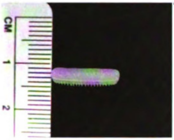

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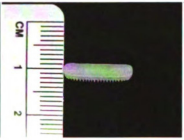

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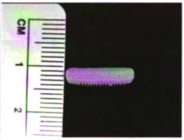

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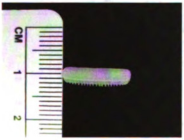

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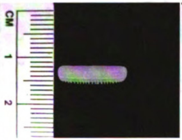

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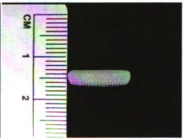

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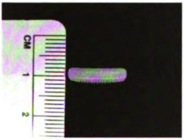

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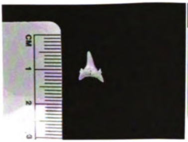
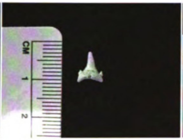
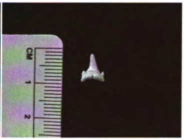

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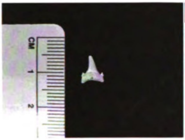
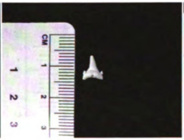
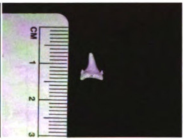

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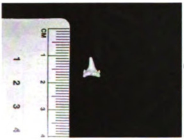
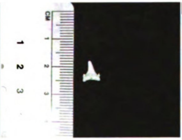
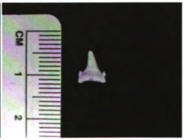

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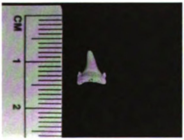
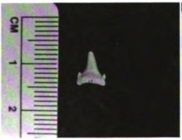
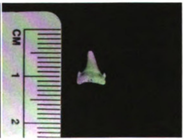

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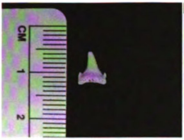

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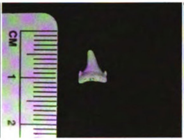

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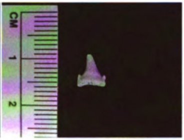

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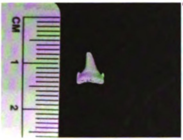

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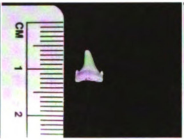

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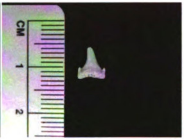

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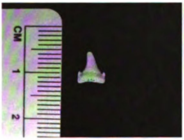

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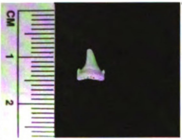

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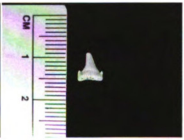

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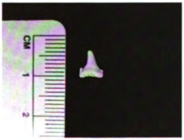

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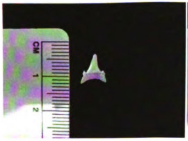

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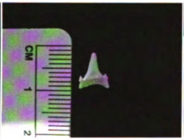

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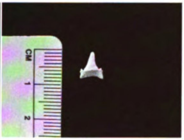

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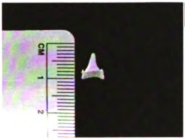

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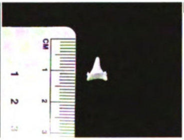

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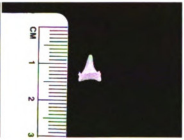

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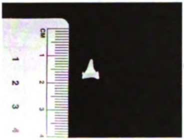

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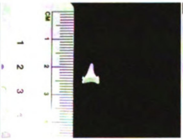

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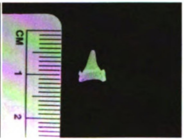

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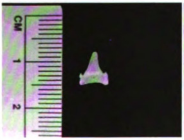

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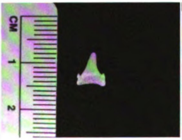

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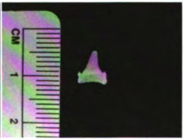

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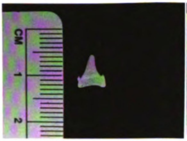

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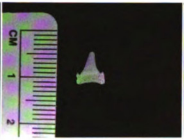

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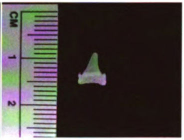

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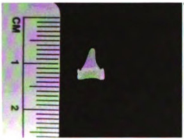

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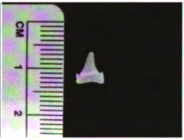

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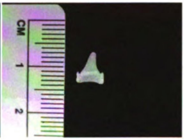

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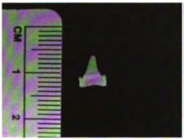

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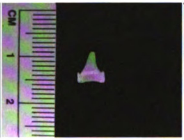

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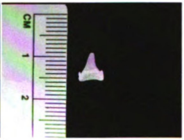

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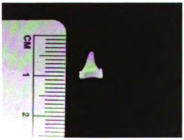

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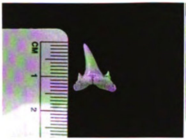

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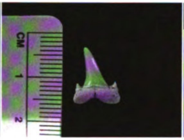

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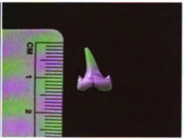

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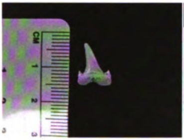

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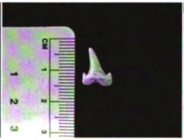

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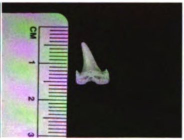

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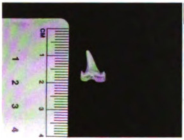

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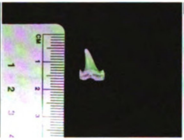

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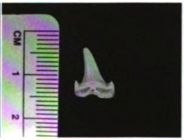

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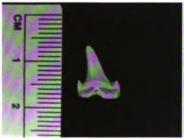

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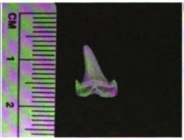

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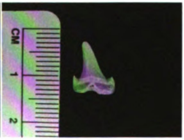

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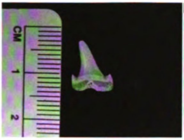

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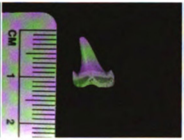

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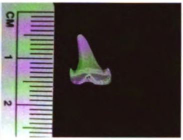

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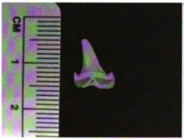

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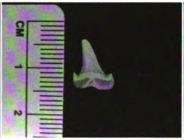

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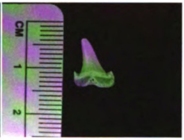

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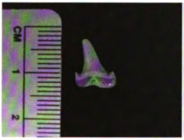

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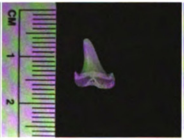

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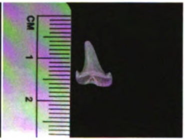

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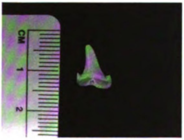

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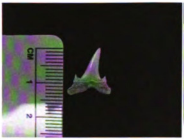

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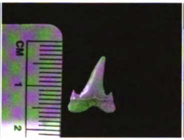

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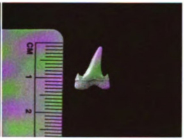

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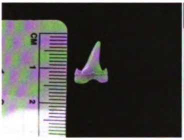

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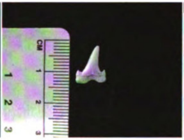

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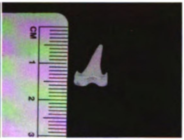

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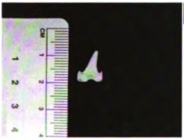

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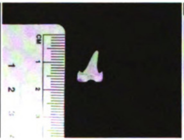

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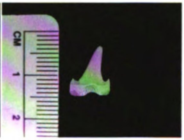

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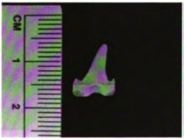

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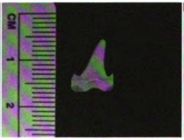

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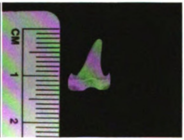

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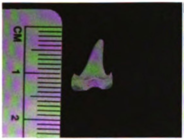

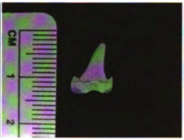

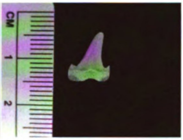

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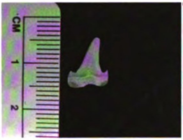

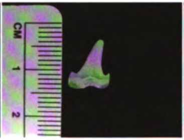

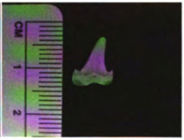

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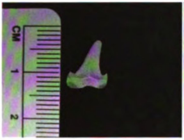

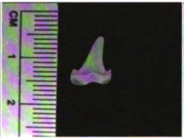

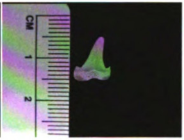

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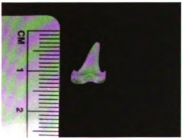

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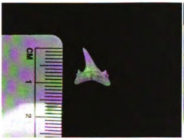

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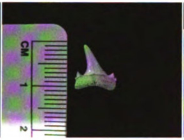

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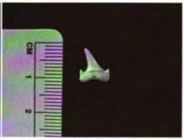

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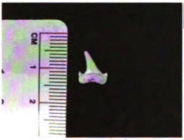

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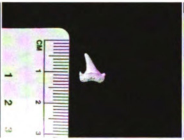

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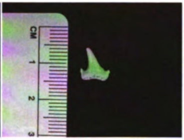

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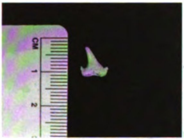

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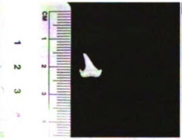

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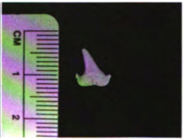

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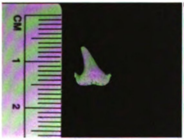

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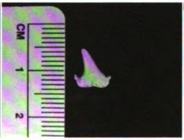

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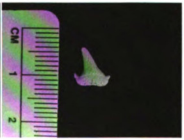

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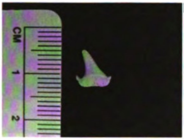

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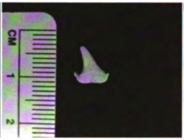

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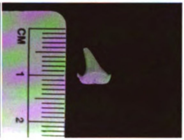

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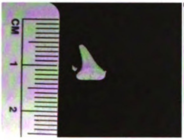

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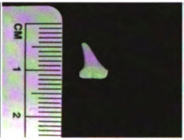

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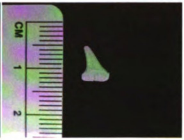

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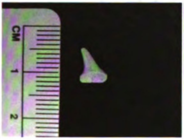

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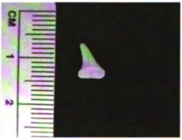

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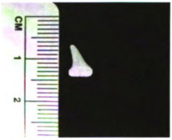

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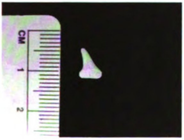

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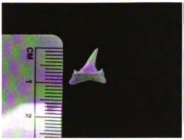

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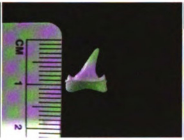

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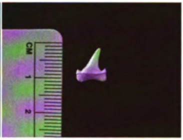

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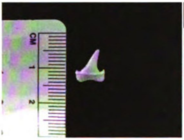

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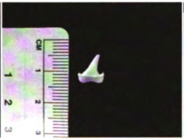

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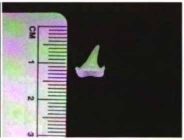

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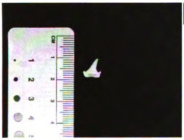

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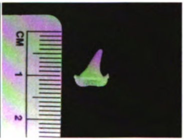

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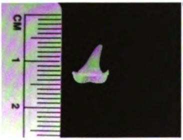

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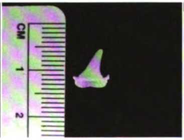

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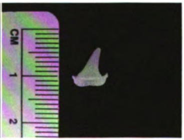

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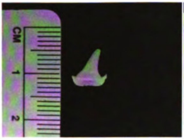

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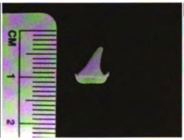

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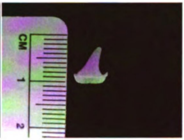

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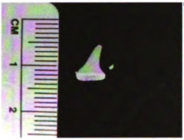

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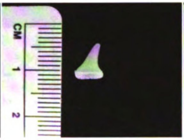

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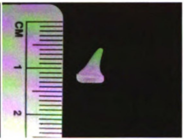

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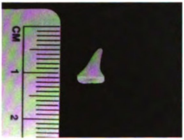

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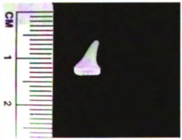

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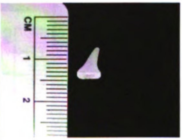

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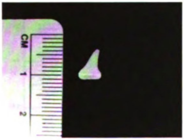

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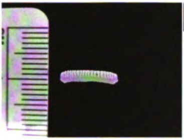 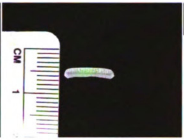 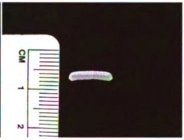

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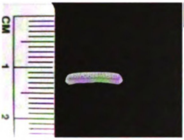 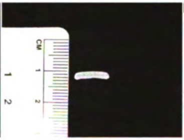 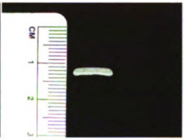

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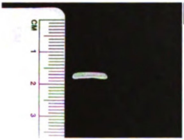 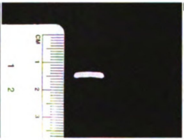 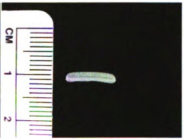

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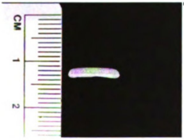 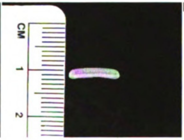 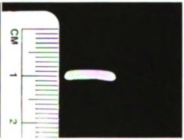

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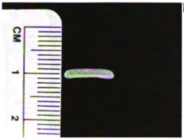

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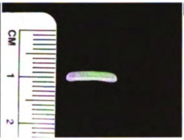

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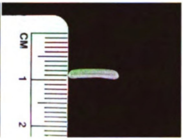

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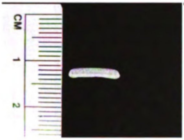

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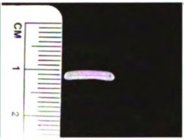

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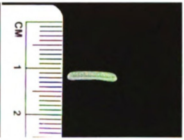

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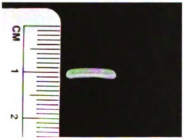

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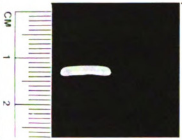

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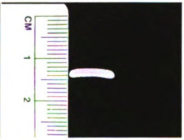

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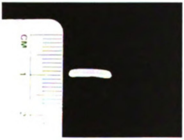

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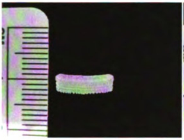

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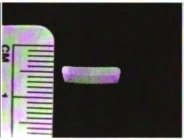

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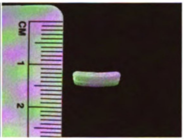

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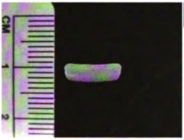

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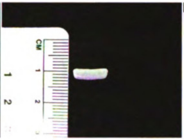

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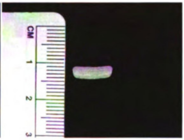

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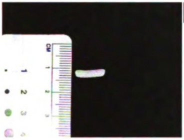

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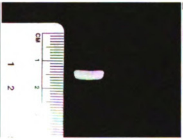

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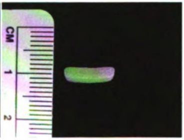

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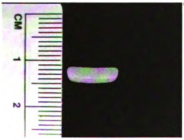

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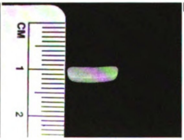

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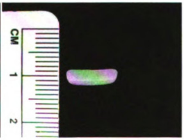

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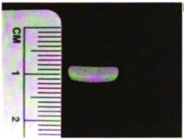

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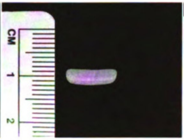

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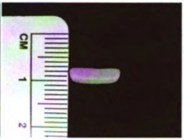

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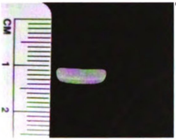

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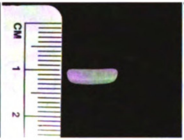

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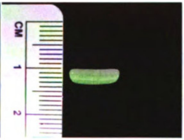

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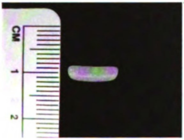

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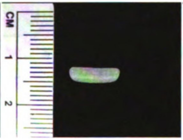

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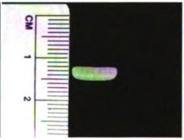

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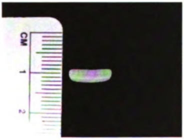

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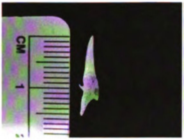

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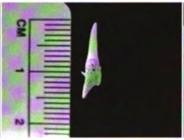

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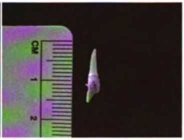

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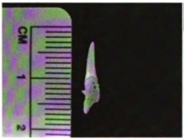

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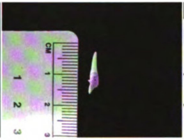

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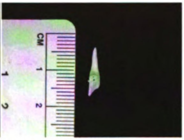

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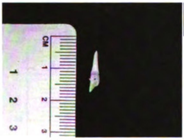

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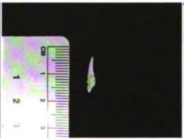

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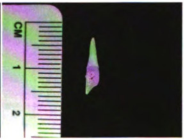

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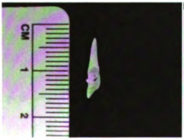

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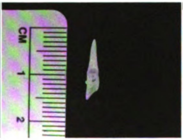

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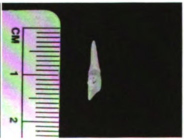

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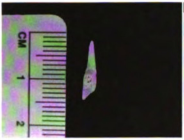

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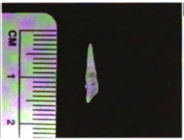

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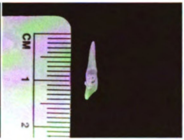

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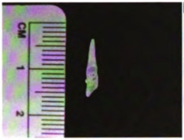

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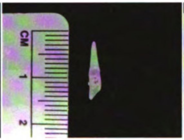

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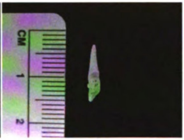

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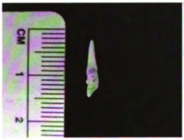

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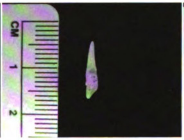

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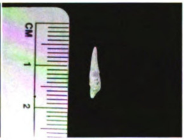

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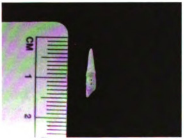

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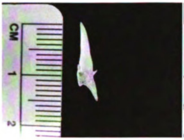

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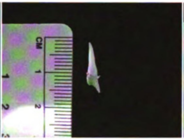

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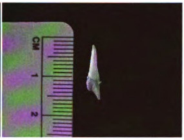

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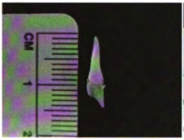

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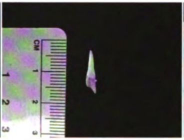

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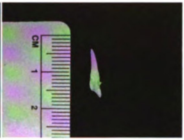

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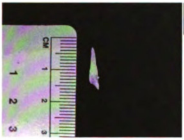

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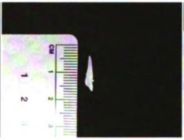

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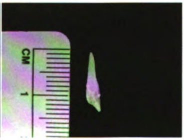

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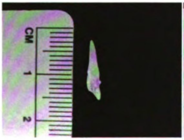

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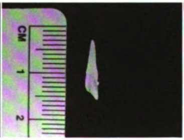

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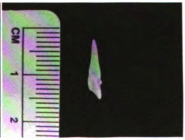

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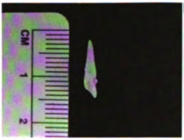

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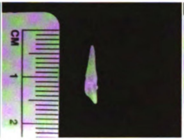

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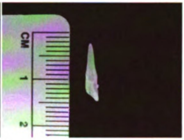

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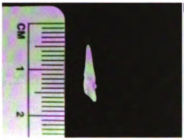

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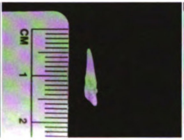

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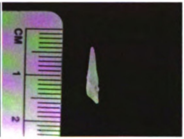

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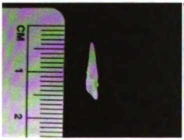

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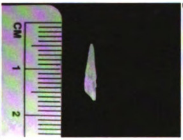

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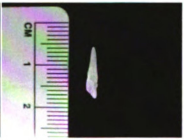

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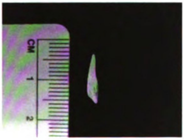

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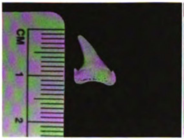

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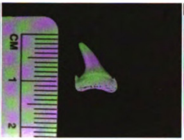

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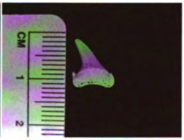

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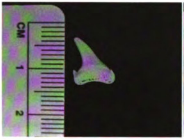

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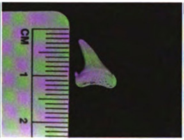

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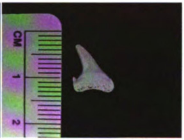

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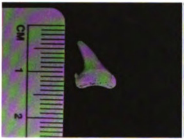

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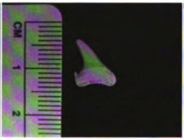

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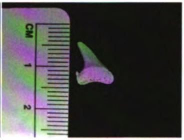

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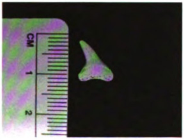

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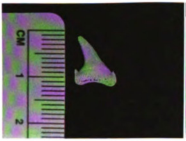

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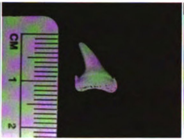

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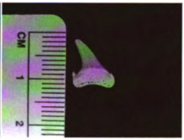

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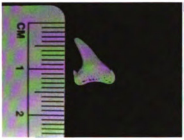

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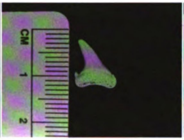

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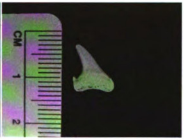

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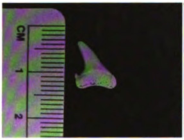

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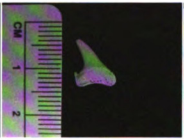

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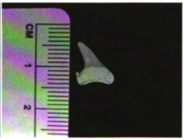

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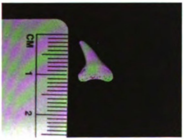

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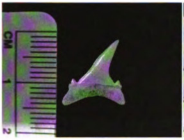
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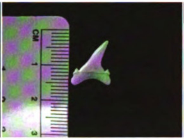
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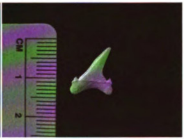
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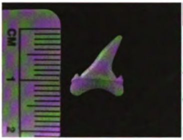
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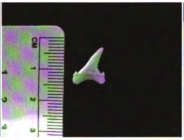
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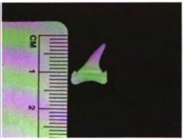
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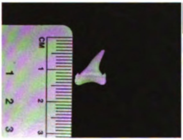
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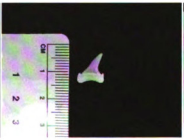
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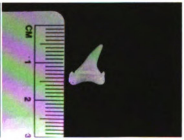
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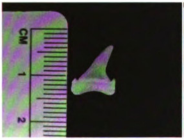
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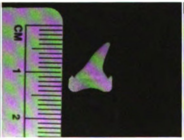
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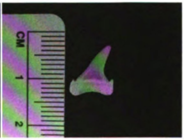
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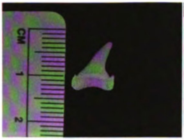

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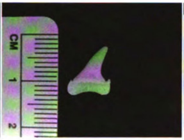

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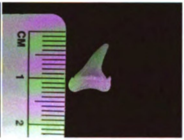

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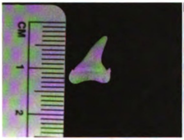

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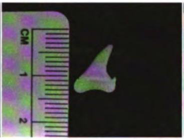

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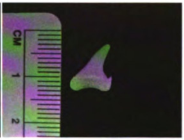

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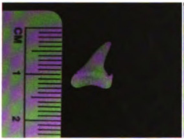

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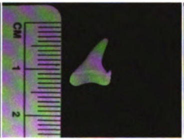

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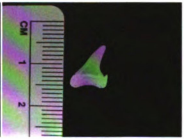

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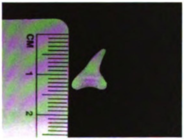

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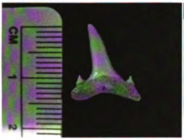

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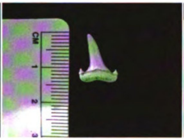

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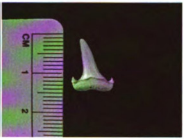

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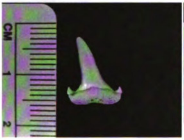

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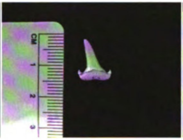

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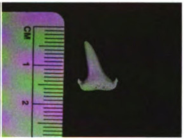

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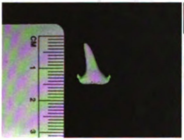

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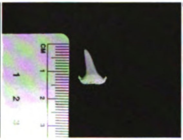

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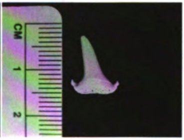

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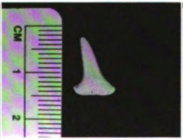

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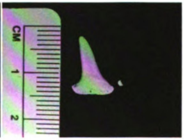

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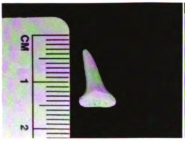

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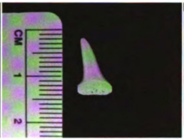

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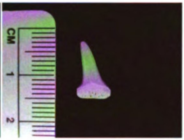

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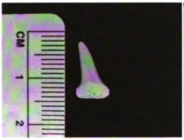

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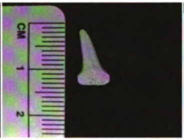

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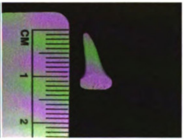

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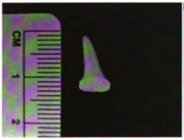

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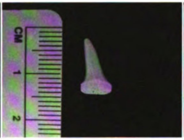

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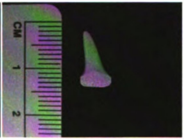

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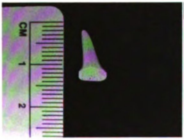

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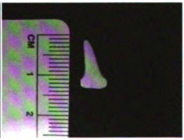

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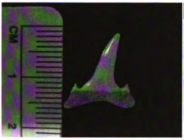

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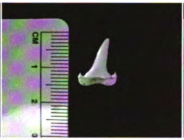

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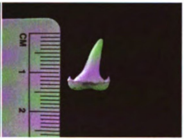

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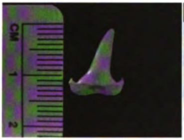

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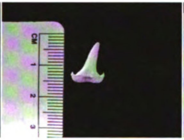

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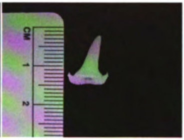

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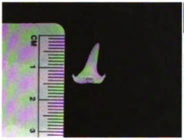

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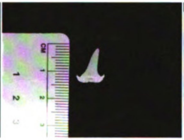

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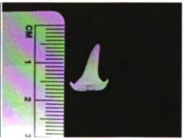

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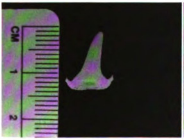

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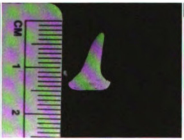

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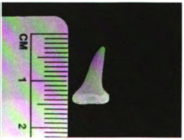

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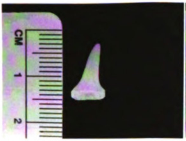

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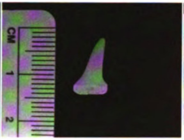

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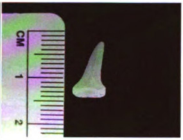

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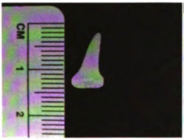

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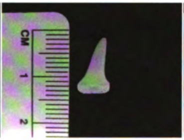

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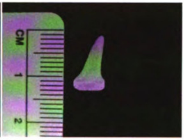

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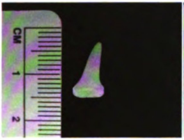

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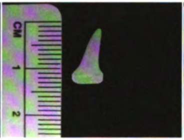

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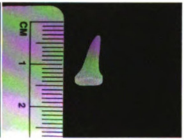

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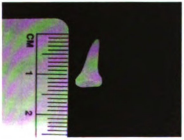

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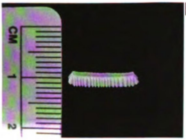

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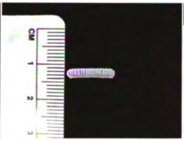

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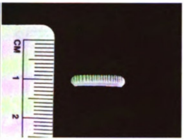

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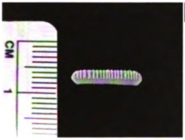

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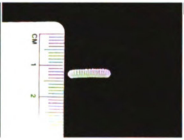

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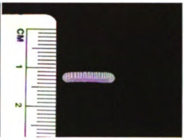

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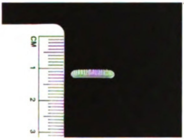

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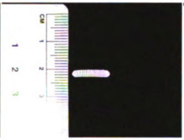

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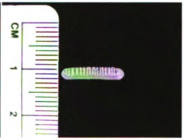

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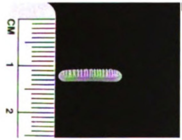

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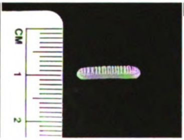

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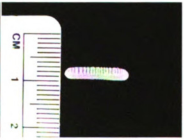

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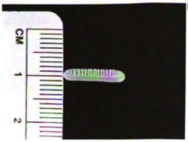

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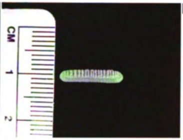

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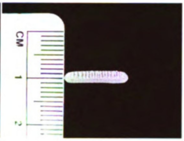

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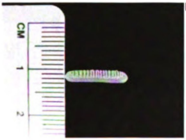

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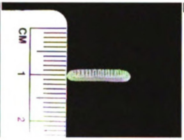

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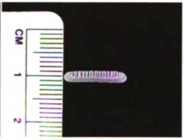

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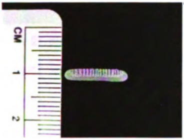

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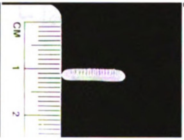

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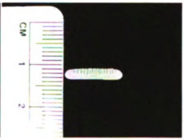

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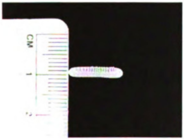

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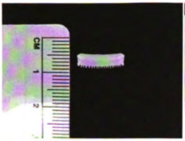

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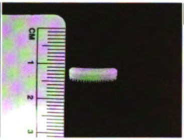

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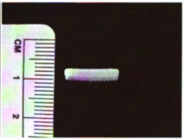

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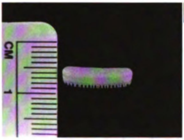

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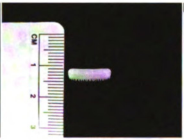

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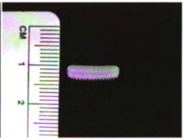

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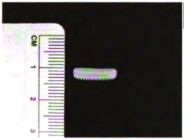

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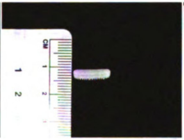

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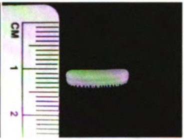

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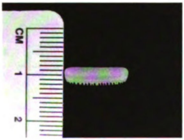

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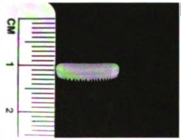

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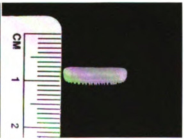

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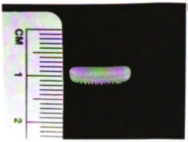

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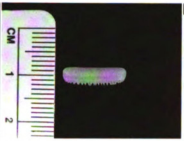

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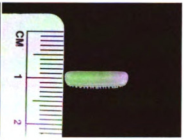

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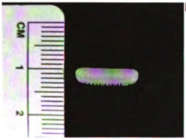

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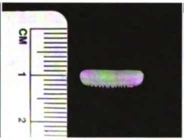

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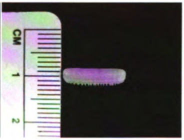

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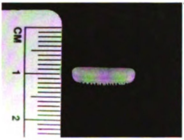

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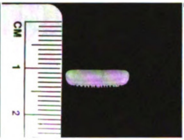

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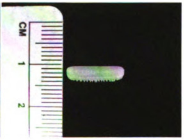

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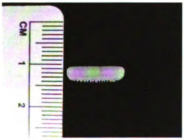

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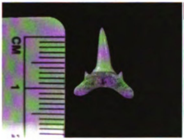

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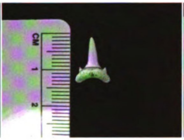

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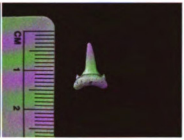

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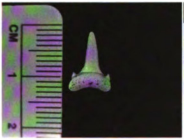

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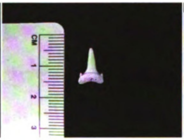

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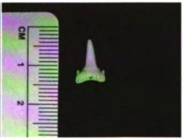

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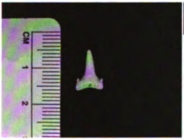

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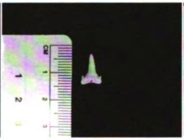

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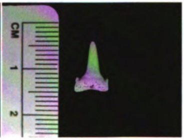

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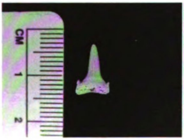

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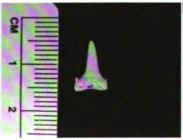

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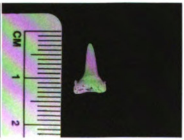

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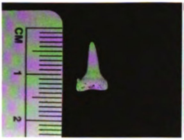

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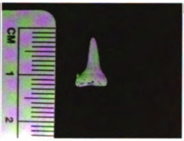

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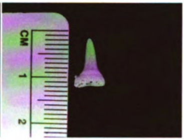

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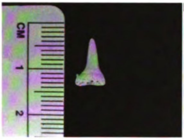

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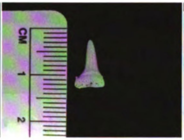

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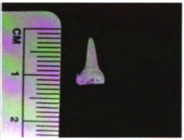

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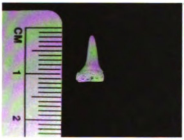

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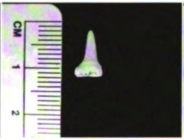

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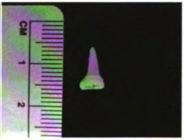

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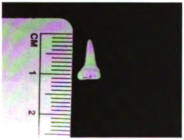

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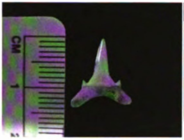
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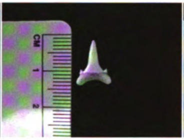
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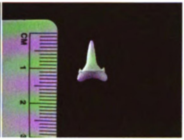
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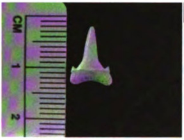
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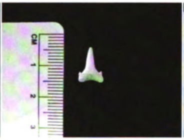
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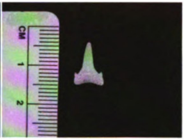
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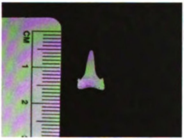
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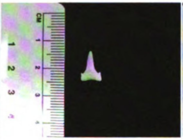
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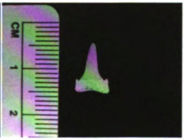
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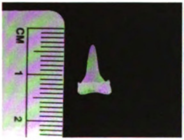
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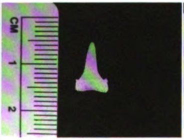
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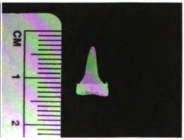
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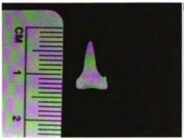

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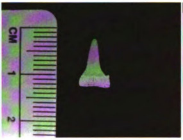

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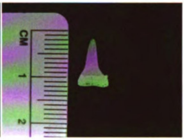

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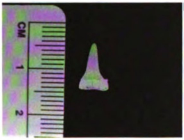

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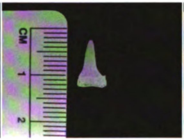

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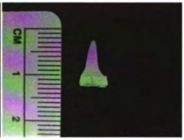

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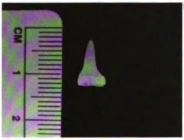

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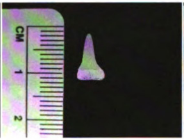

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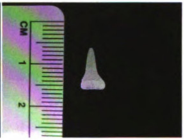

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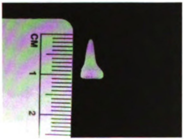

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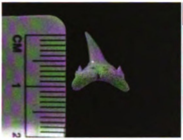

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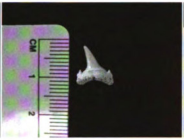

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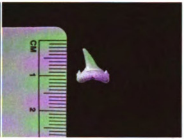

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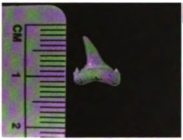

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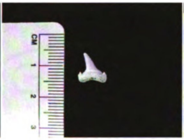

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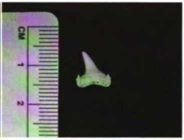

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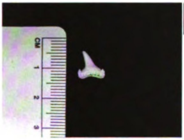

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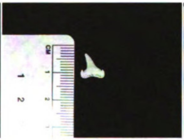

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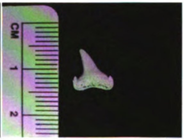

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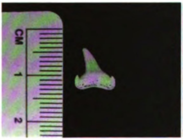

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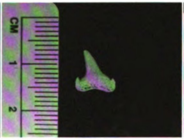

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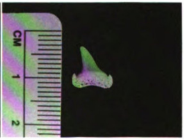

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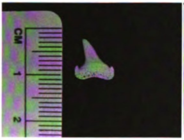

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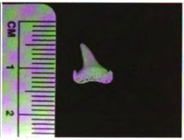

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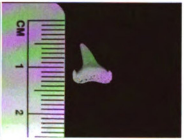

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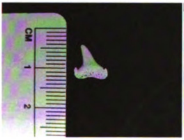

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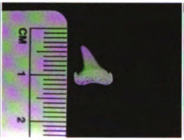

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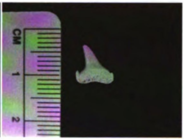

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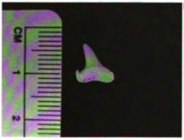

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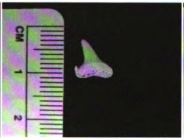

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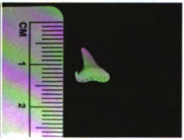

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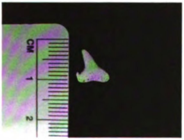

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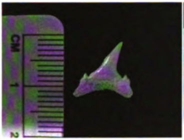

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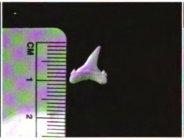

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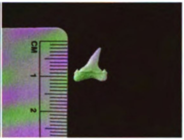

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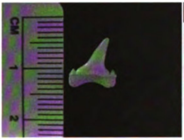

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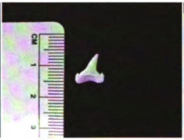

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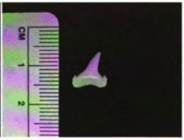

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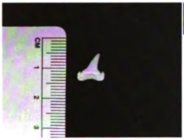

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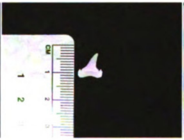

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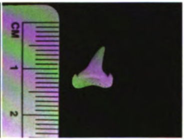

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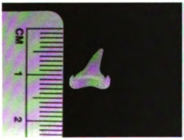

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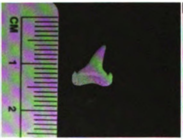

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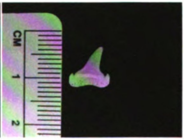

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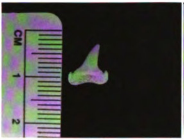

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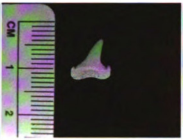

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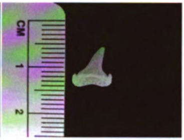

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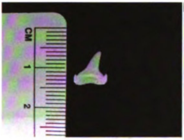

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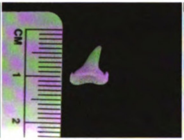

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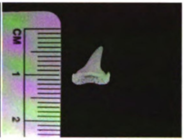

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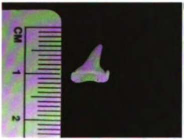

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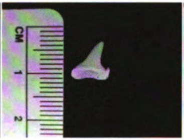

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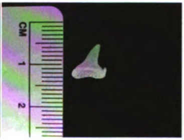

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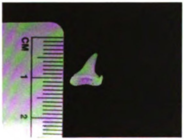

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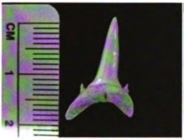

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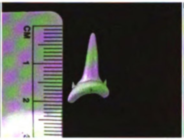

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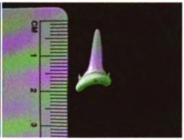

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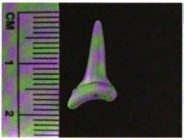

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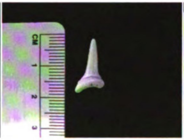

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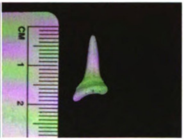

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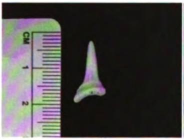

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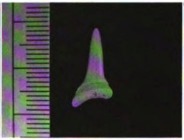

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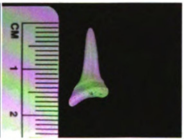

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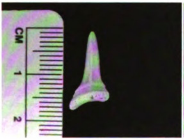

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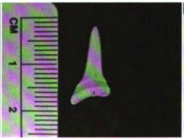

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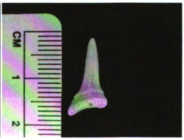

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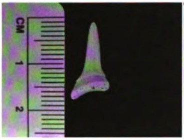

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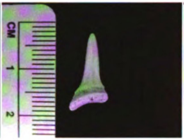

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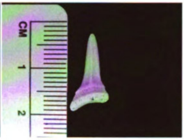

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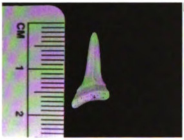

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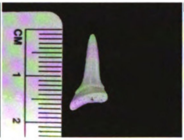

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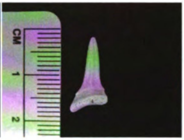

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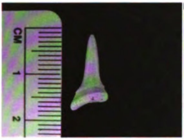

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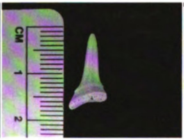

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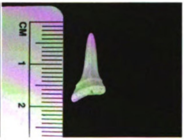

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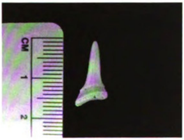

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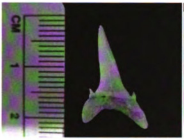

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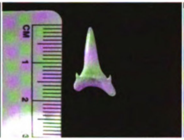

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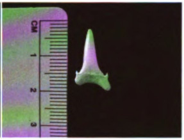

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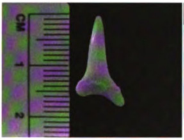

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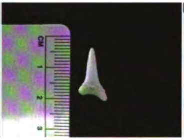

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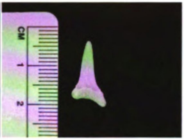

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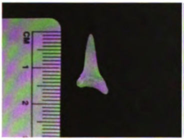

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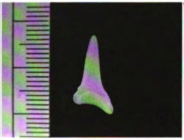

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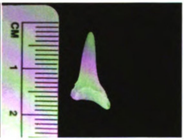

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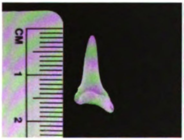

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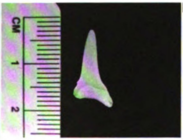

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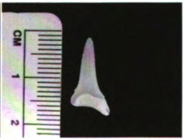

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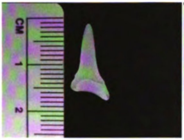

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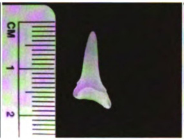

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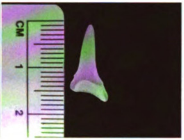

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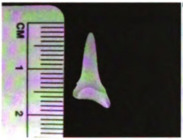

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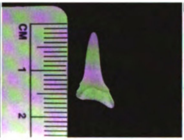

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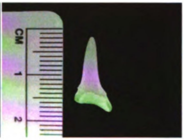

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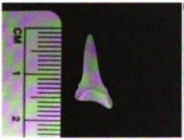

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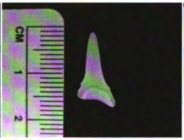

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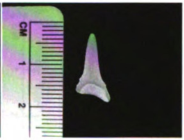

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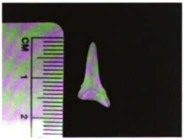

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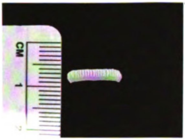

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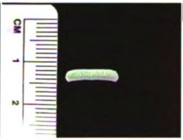

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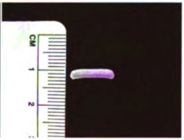

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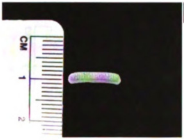

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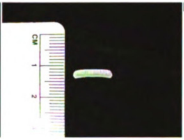

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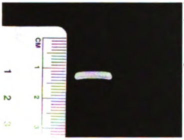

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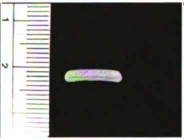

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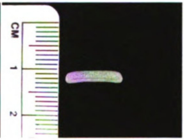

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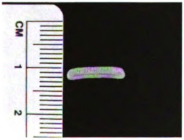

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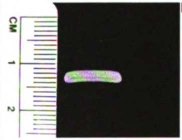

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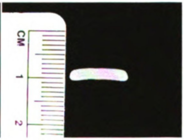

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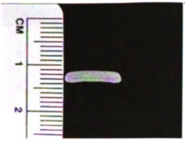

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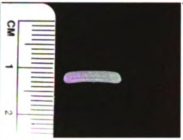

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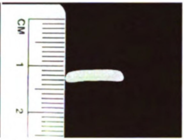

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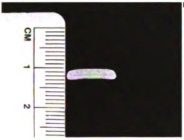

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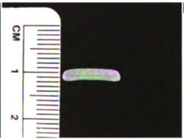

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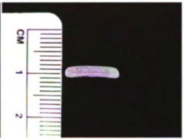

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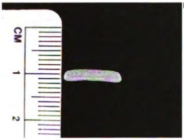

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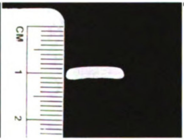

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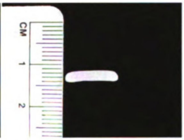

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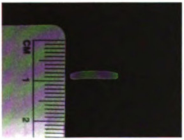

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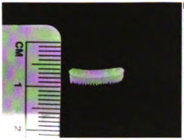

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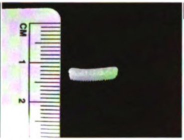

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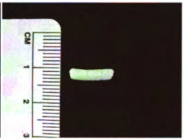

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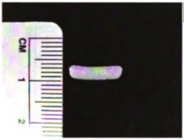

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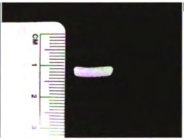

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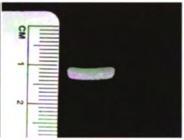

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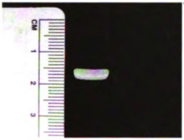

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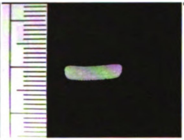

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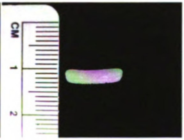

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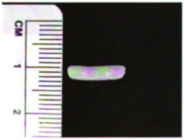

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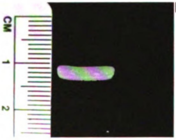

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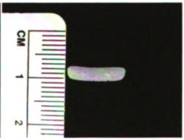

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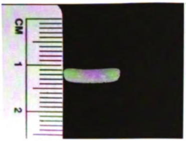

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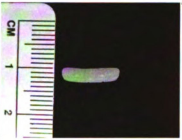

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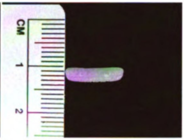

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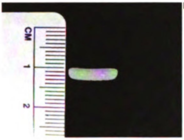

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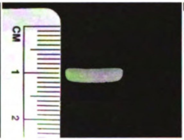

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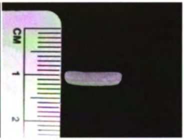

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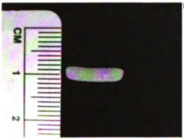

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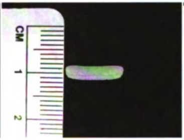

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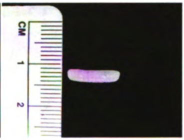

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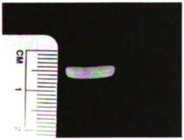

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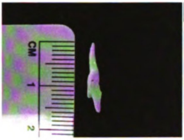 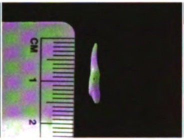 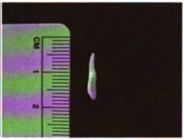

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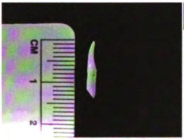 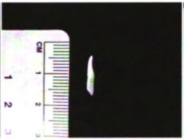 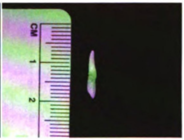

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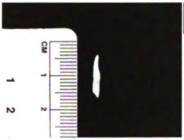 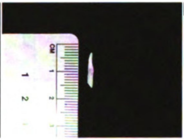 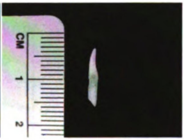

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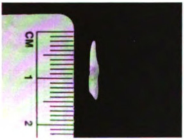 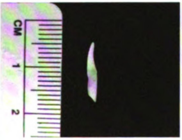 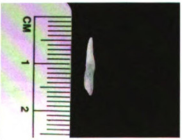

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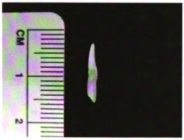

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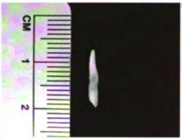

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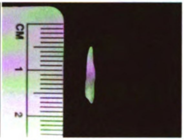

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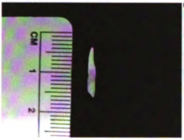

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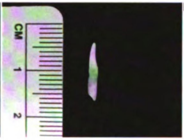

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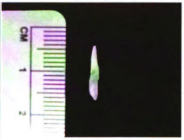

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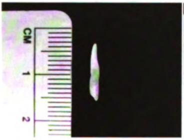

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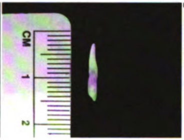

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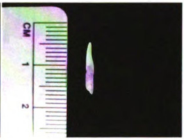

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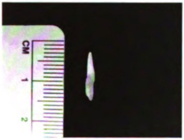

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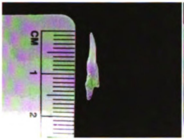

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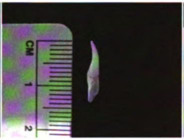

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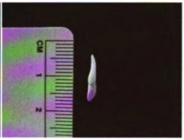

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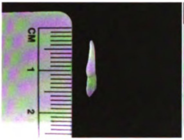

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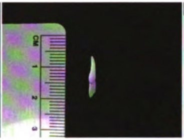

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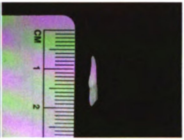

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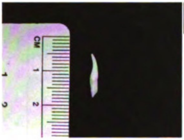

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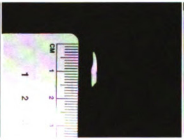

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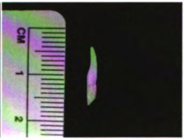

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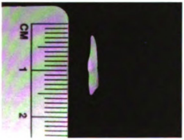

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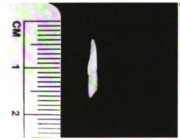

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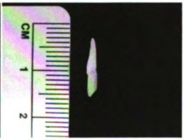

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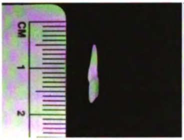

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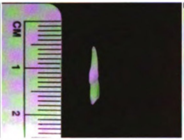

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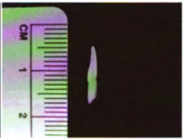

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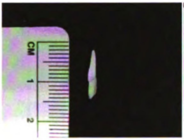

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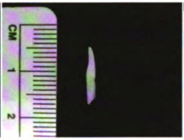

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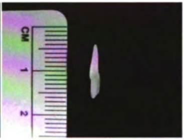

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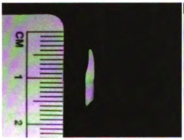

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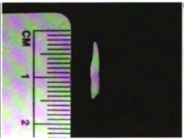

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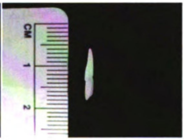

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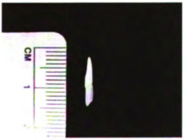

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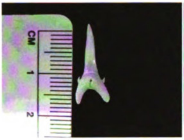

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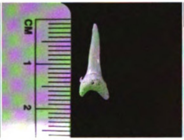

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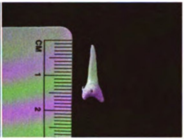

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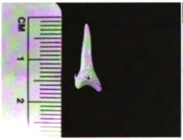

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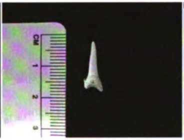

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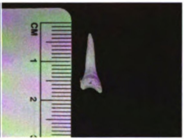

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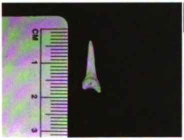

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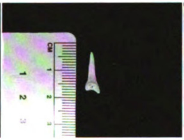

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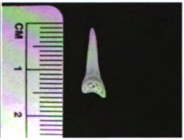

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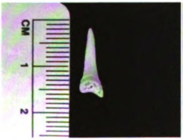

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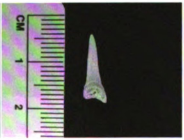

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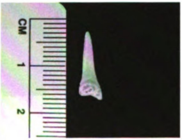

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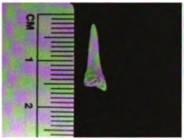

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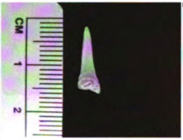

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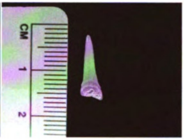

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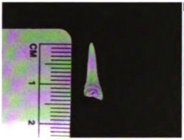

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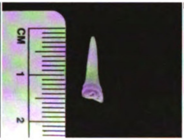

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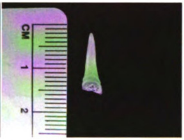

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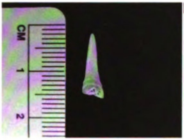

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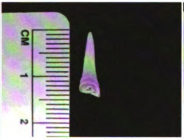

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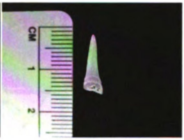

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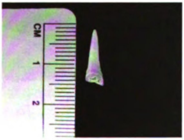

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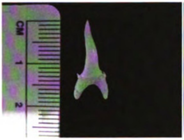

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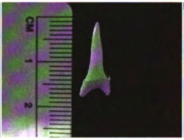

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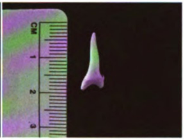

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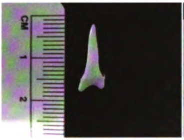

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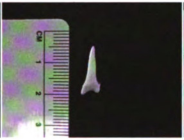

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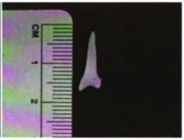

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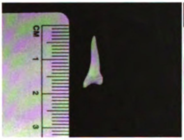

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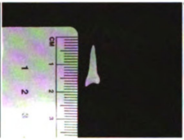

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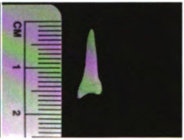

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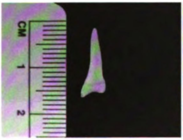

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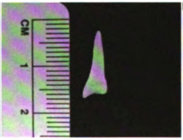

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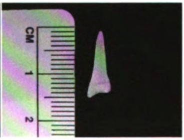

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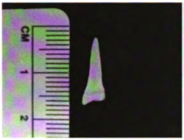

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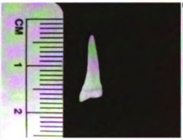

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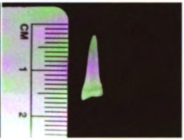

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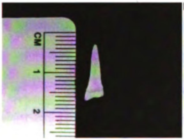

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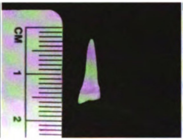

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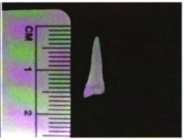

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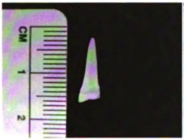

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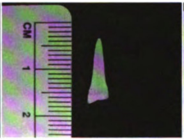

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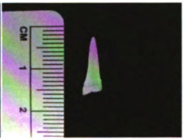

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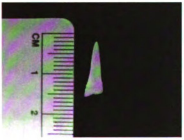

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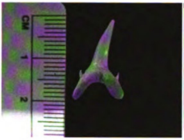

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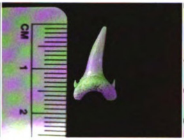

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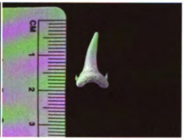

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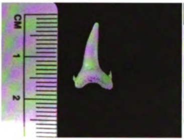

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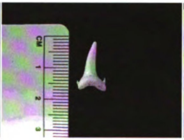

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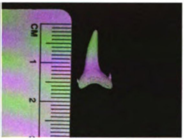

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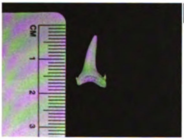

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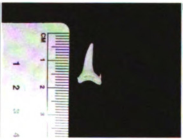

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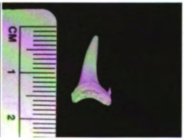

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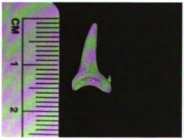

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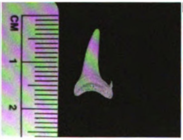

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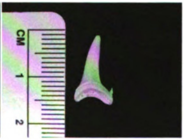

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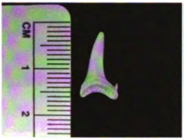

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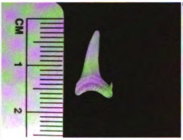

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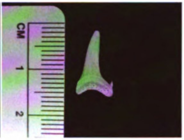

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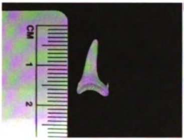

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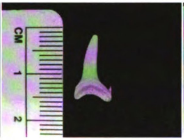

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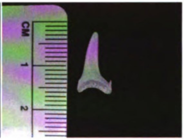

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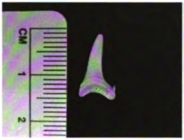

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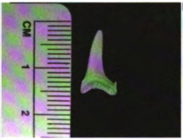

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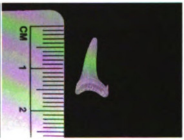

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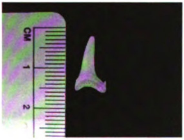

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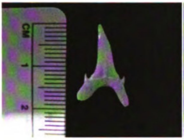

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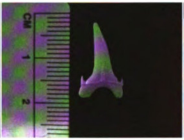

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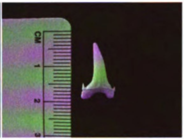

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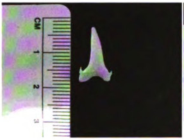

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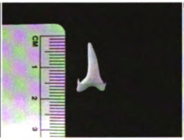

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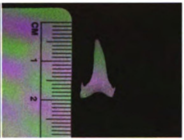

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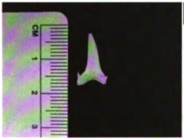

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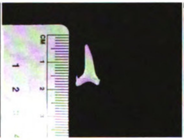

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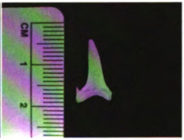

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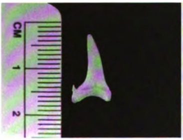

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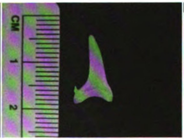

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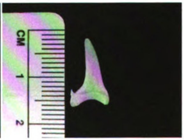

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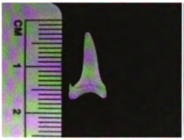

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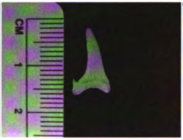

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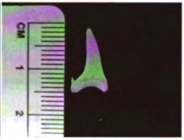

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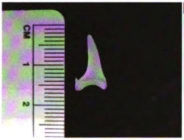

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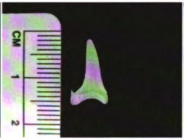

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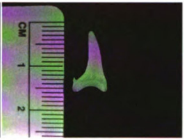

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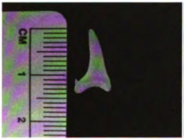

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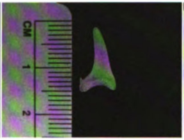

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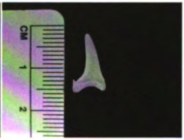

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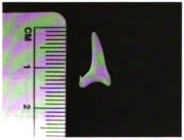

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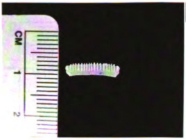

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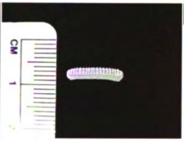

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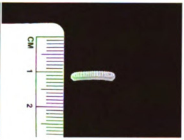

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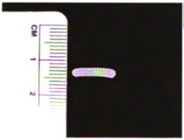

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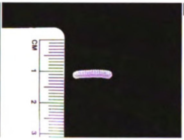

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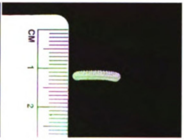

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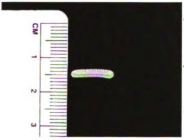

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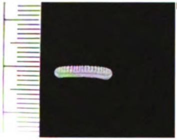

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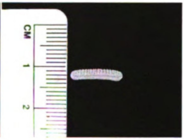

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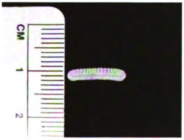

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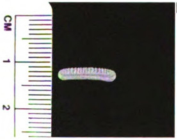

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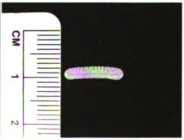

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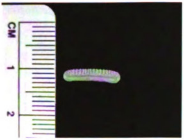

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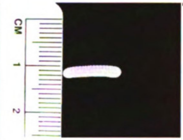

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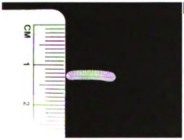

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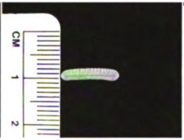

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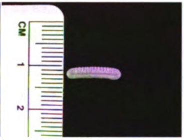

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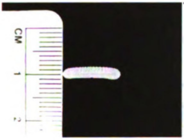

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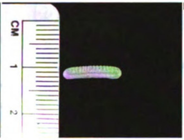

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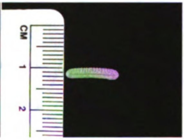

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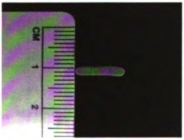

1050E4root.jpg

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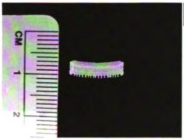
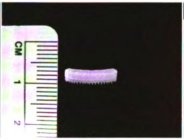
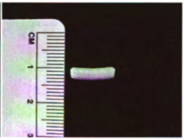
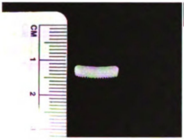
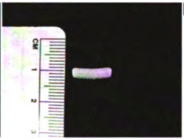
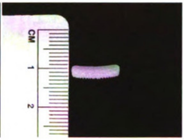
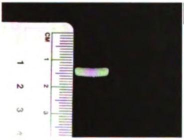
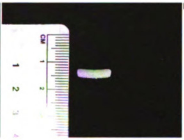
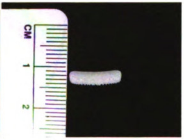




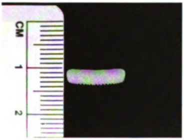
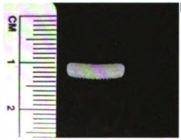
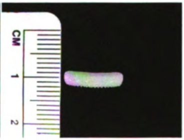
0E4side.jpg | 50E4side.jpg | 100E4side.jpg

150E4side.jpg | 200E4side.jpg | 250E4side.jpg

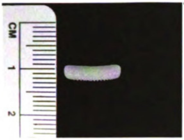




300E4side.jpg | 350E4side.jpg | 400E4side.jpg

450E4side.jpg | 500E4side.jpg | 550E4side.jpg

Appendix G continued.



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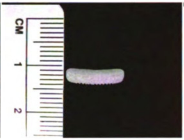

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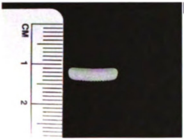

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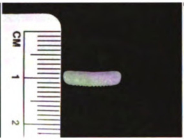

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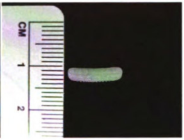

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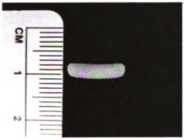

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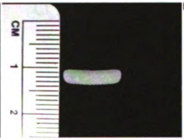

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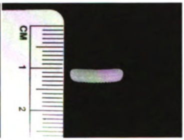

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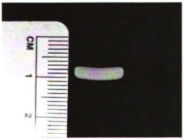

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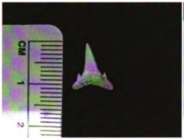

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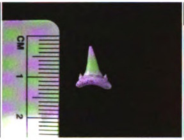

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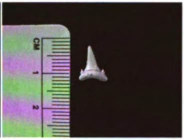

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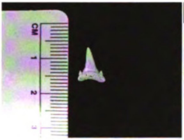

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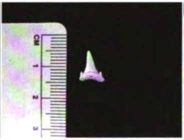

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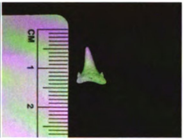

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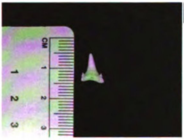

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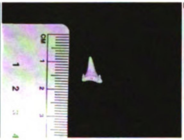

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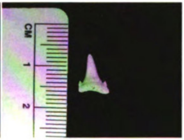

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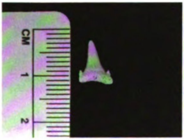

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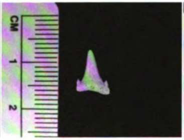

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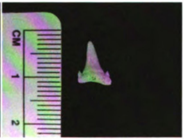

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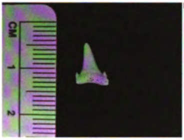

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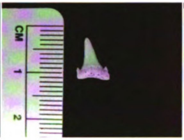

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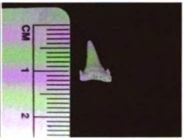

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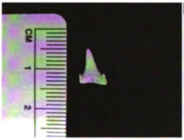

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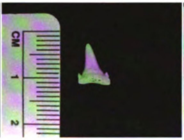

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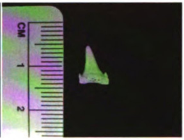

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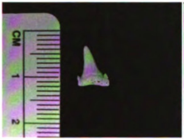

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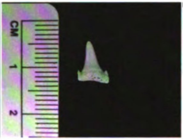

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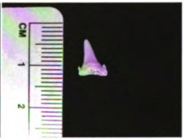

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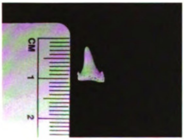

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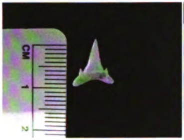

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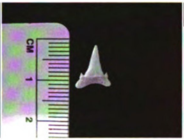

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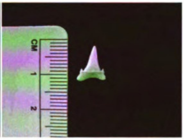

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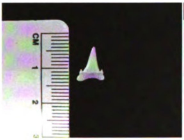

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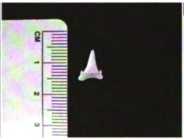

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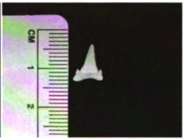

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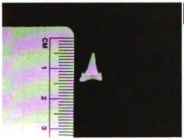

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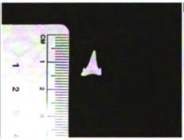

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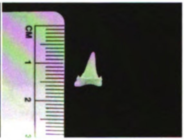

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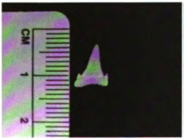

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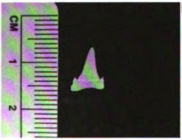

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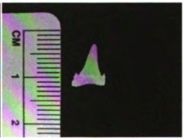

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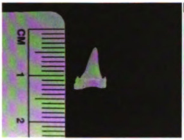

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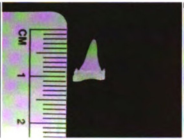

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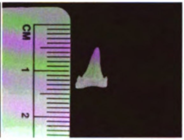

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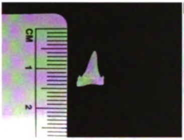

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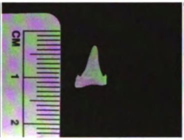

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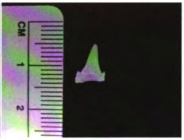

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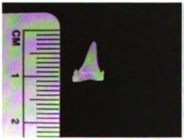

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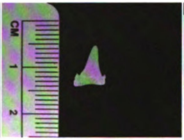

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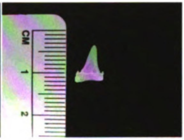

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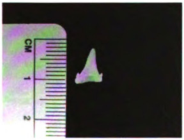

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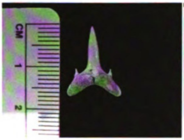

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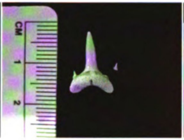

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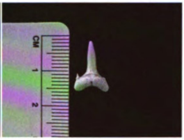

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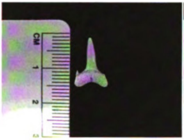

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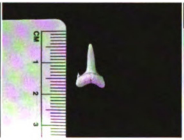

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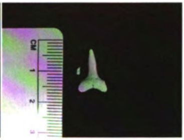

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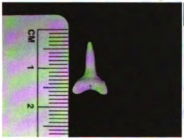

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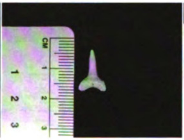

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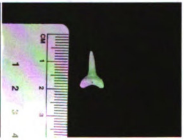

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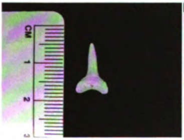

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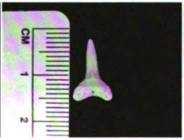

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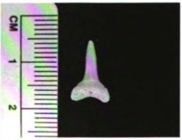

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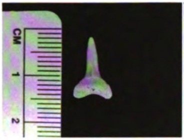

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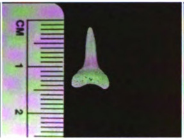

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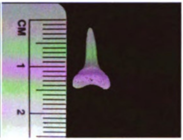

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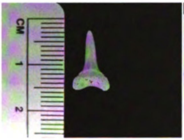

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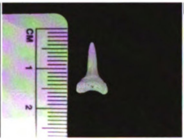

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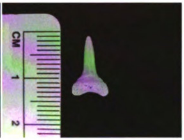

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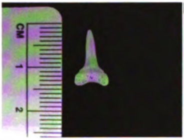

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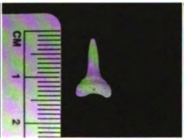

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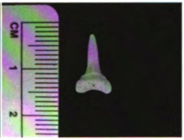

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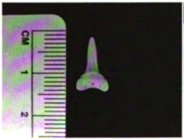

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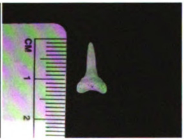

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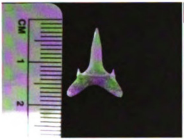

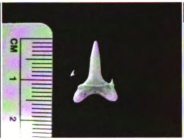

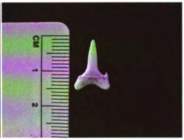

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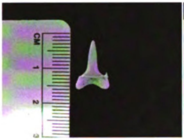

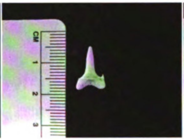

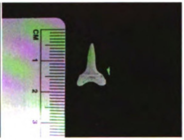

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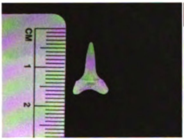

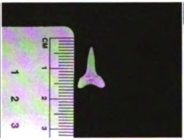

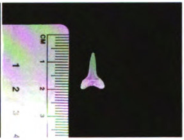

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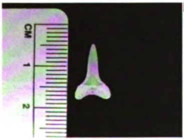

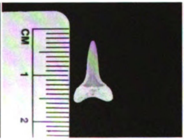

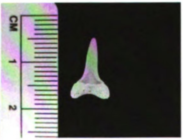

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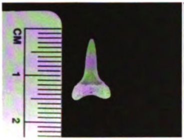

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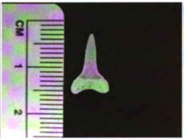

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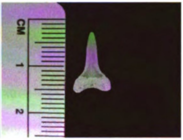

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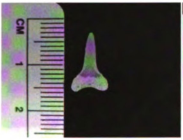

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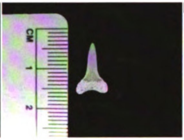

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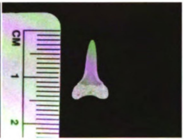

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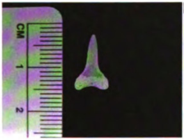

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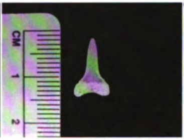

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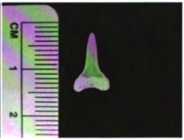

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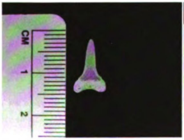

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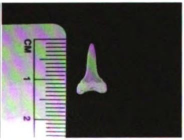

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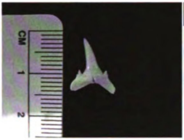

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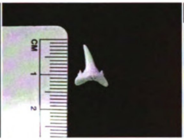

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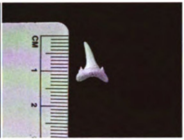

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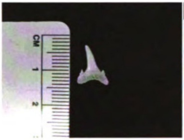

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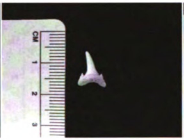

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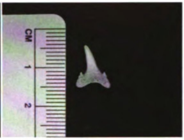

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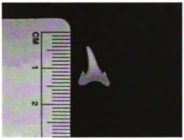

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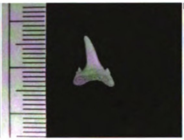

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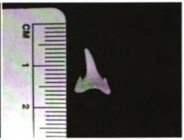

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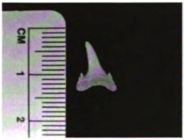

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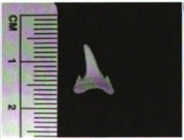

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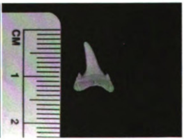

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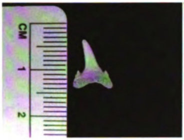

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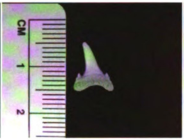

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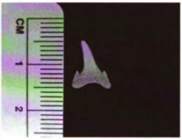

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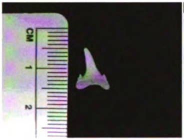

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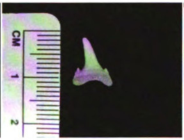

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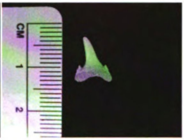

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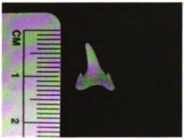

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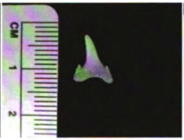

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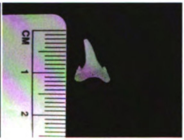

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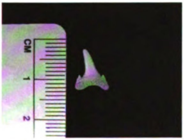

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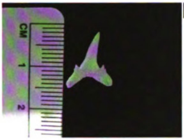

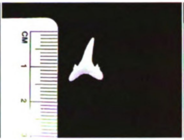

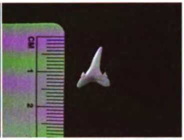

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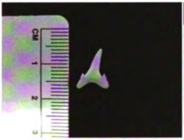

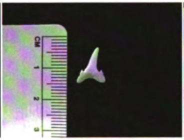

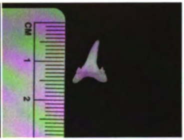

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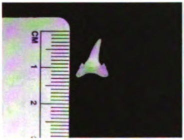

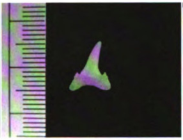

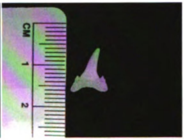

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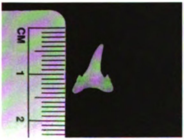

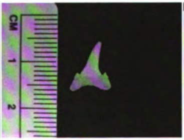

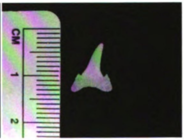

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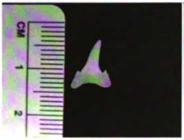

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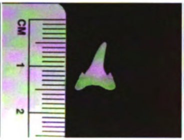

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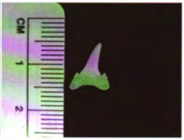

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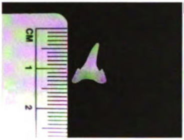

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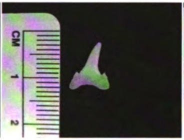

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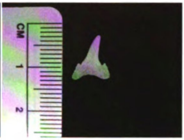

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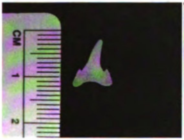

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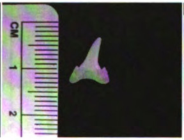

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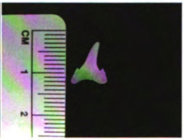

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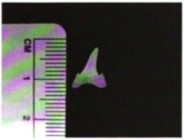

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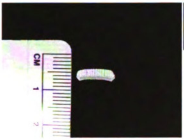

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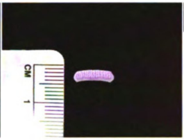

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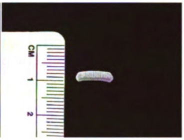

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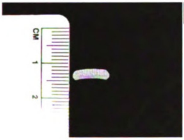

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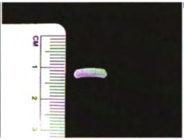

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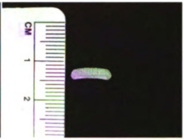

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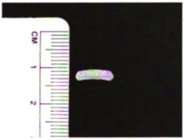

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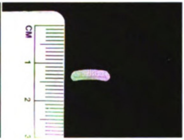

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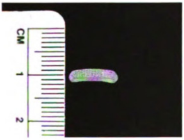

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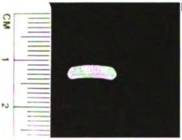

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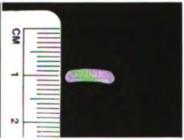

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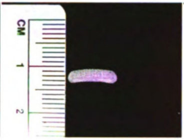

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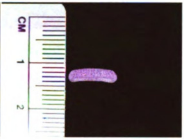

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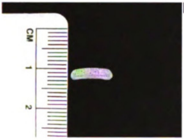

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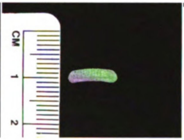

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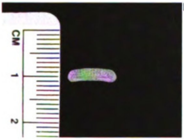

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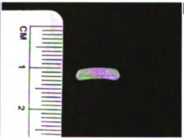

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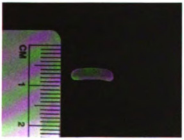

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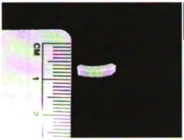

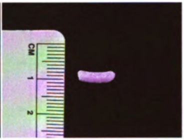

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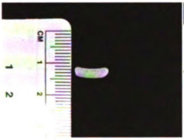

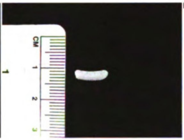

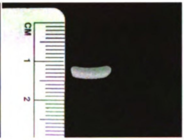

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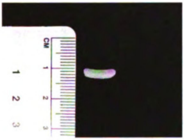

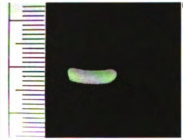

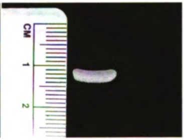

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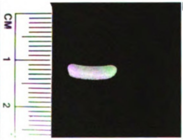

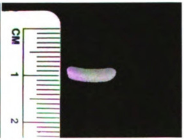

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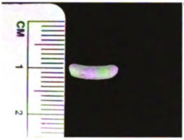

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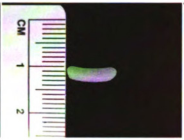

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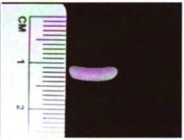

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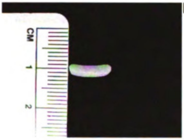

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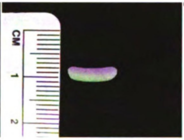

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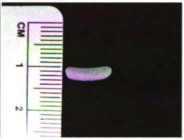

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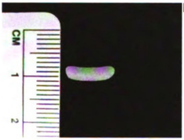

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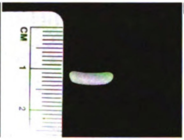

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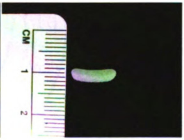

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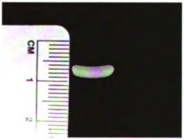

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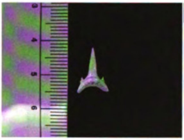

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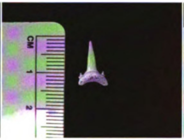

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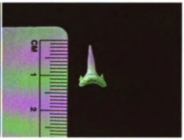

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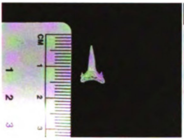

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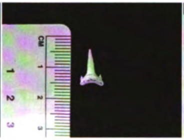

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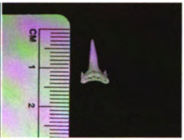

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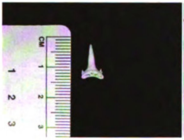

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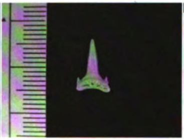

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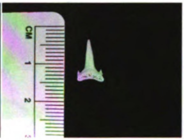

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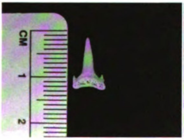

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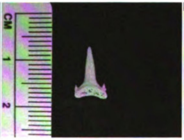

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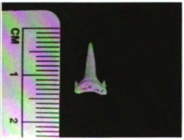

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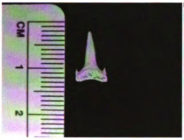

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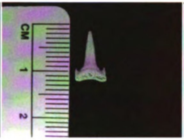

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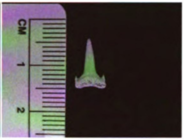

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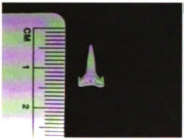

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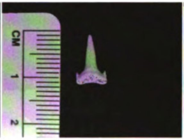

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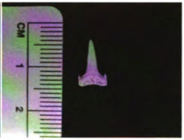

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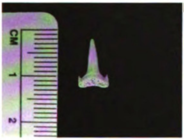

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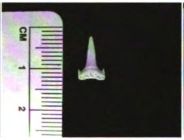

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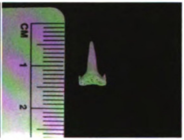

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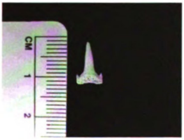

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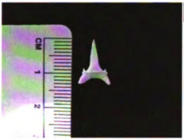

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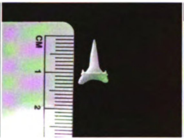

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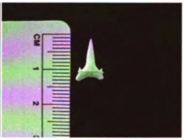

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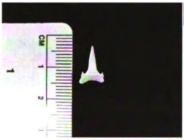

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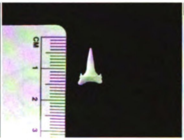

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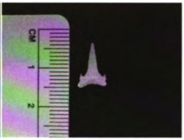

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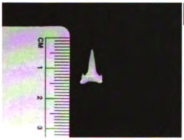

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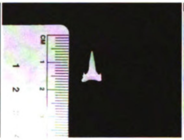

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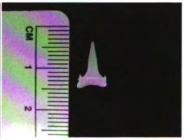

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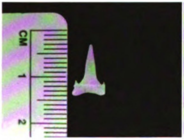

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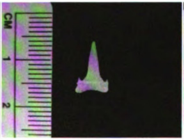

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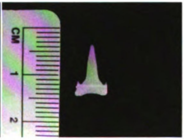

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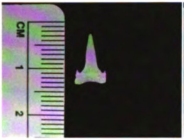

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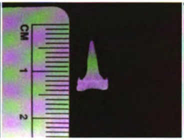

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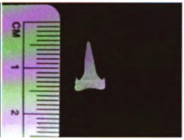

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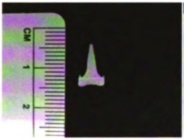

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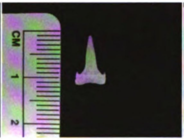

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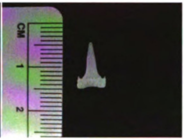

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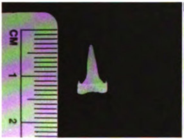

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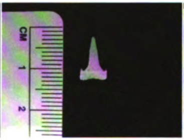

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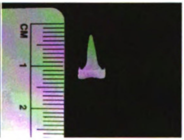

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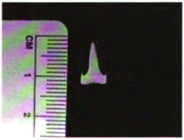

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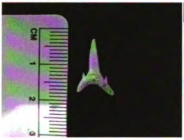

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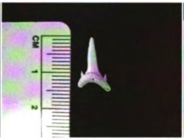

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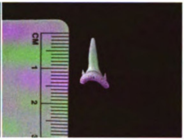

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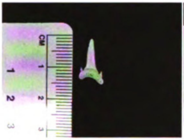

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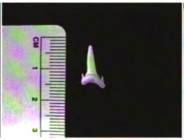

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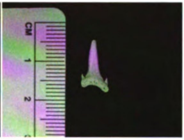

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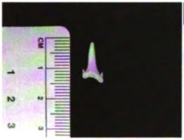

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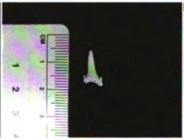

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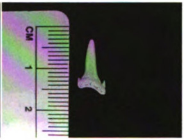

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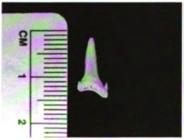

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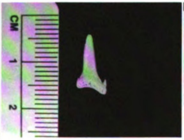

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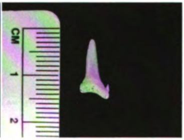

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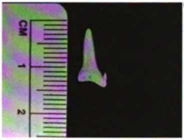

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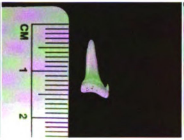

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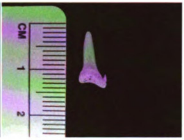

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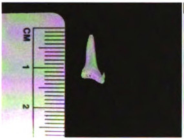

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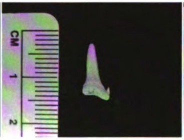

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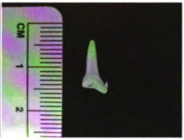

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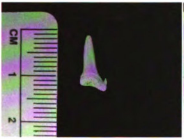

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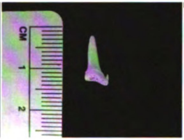

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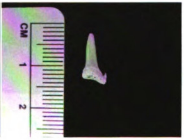

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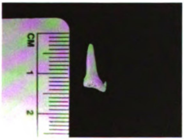

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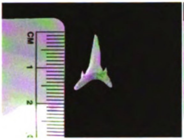
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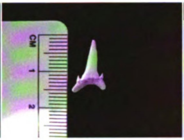
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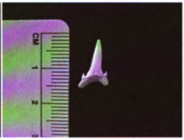
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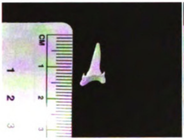
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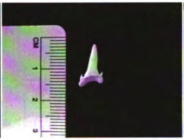
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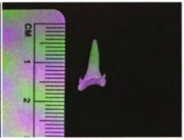
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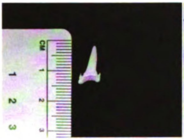
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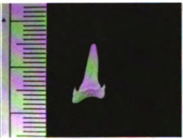
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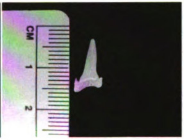
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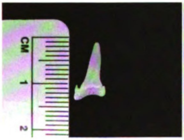
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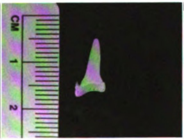
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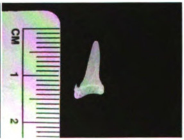
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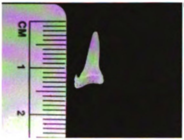

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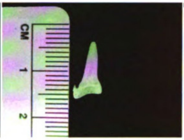

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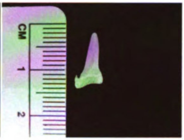

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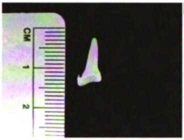

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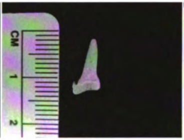

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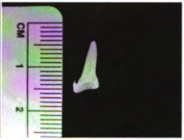

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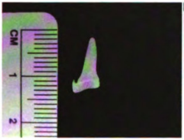

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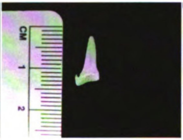

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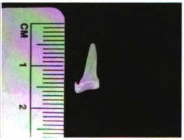

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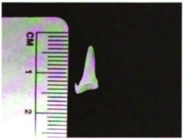

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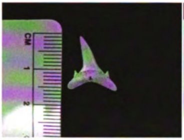

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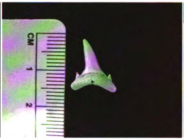

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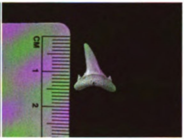

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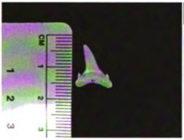

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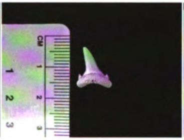

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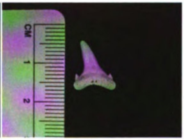

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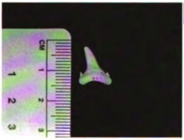

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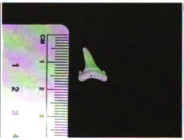

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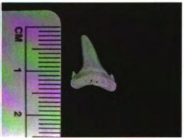

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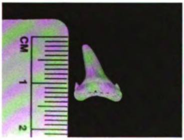

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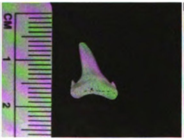

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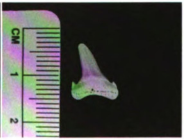

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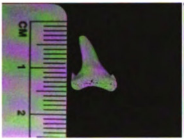

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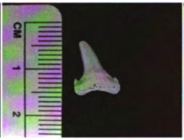

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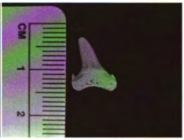

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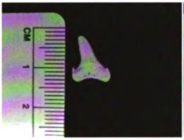

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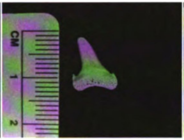

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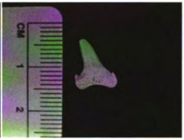

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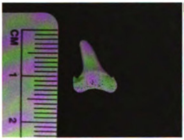

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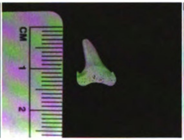

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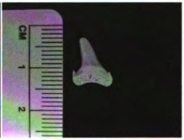

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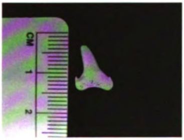

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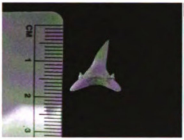

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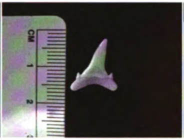

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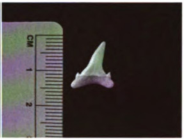

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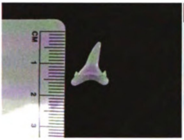

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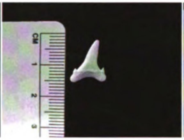

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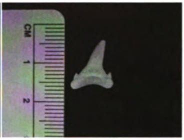

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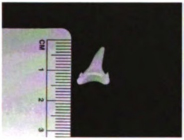

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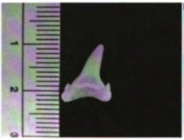

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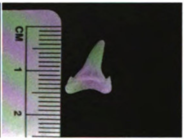

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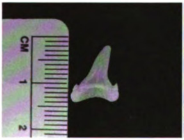

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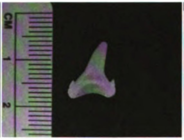

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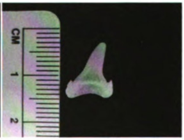

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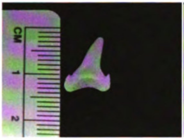

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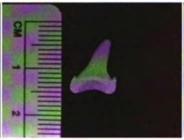

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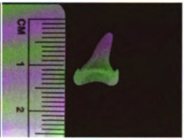

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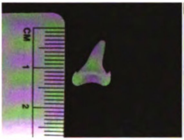

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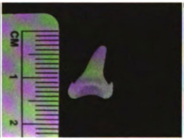

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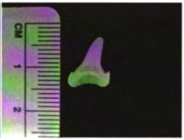

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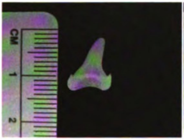

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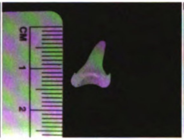

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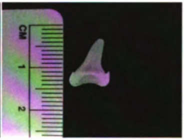

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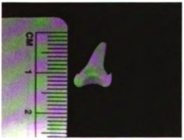

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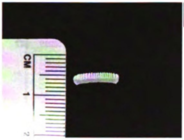

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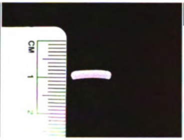

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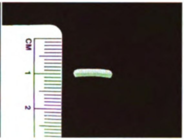

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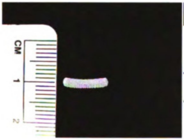

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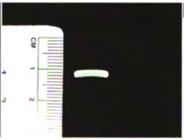

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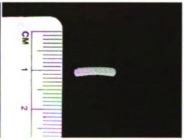

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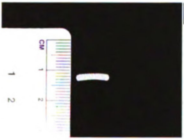

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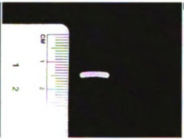

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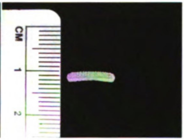

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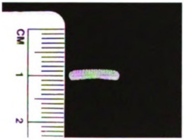

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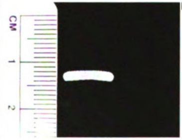

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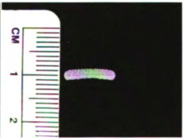

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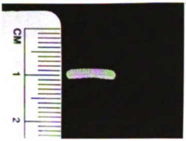

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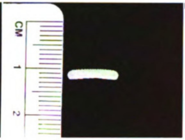

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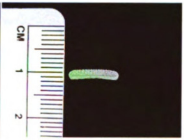

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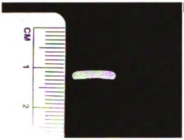

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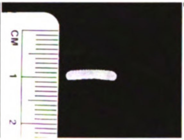

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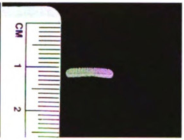

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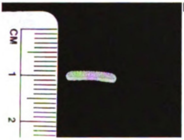

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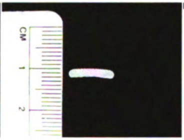

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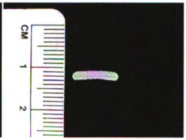

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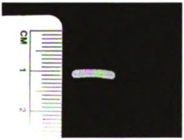

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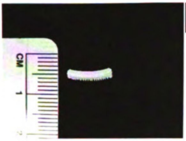

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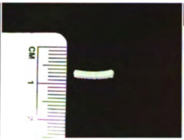

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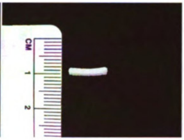

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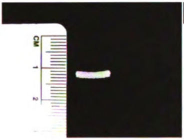

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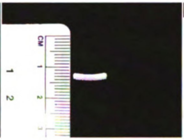

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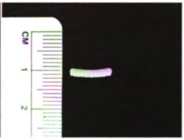

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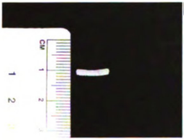

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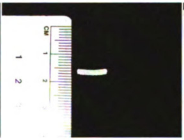

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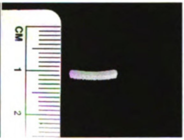

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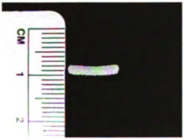

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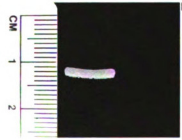

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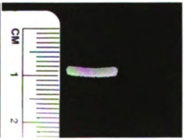

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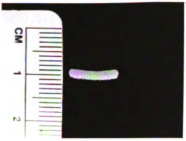

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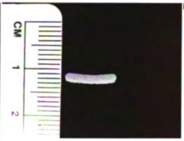

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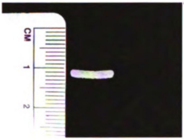

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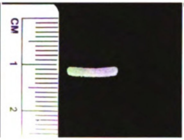

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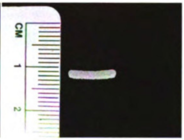

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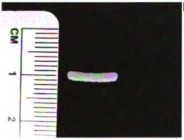

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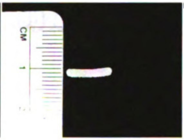

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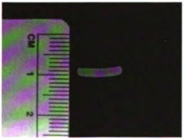

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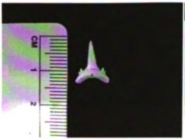

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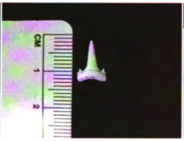

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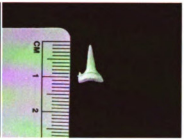

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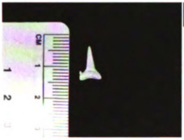

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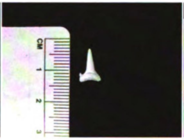

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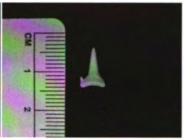

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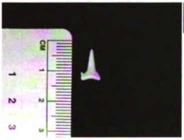

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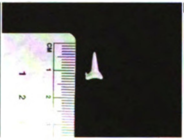

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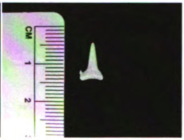

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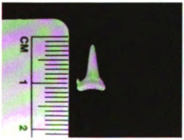

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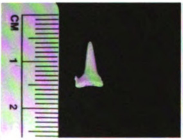

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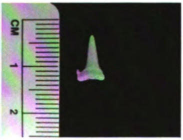

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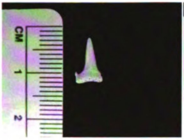

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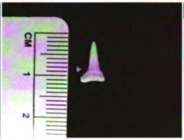

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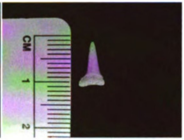

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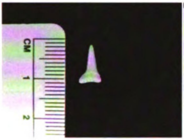

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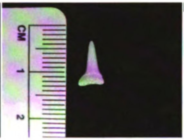

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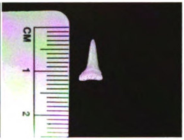

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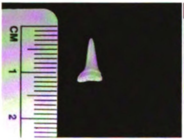

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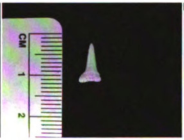

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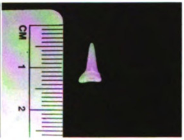

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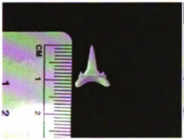

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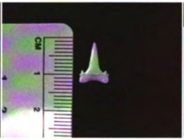

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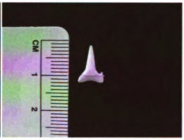

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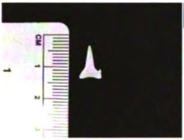

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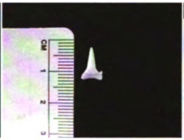

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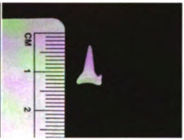

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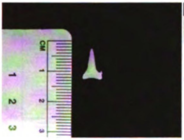

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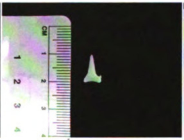

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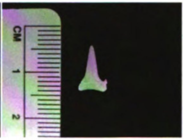

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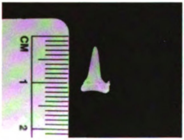

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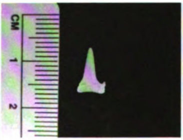

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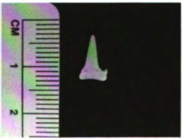

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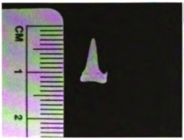

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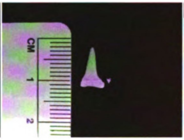

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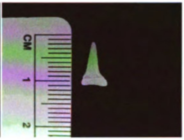

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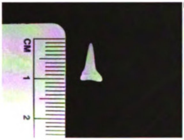

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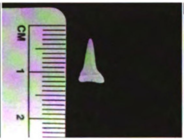

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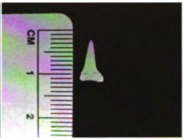

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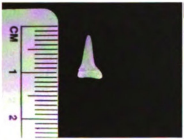

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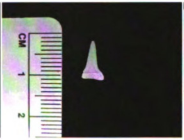

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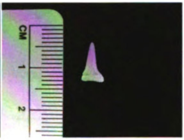

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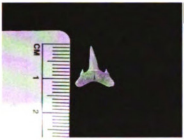

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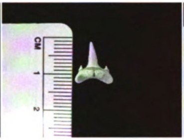

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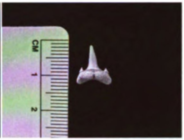

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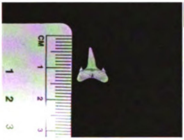

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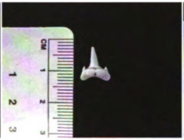

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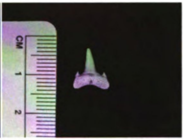

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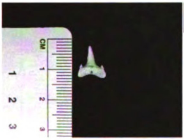

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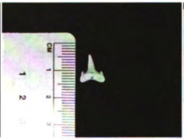

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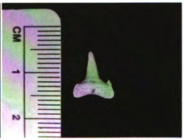

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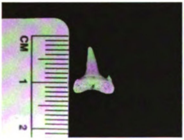

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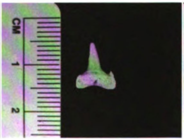

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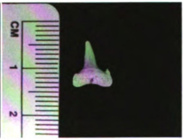

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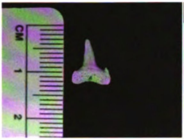

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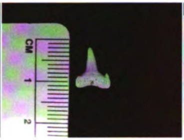

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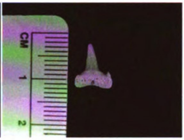

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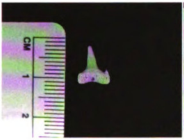

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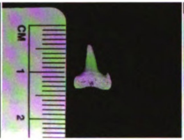

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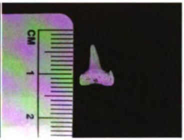

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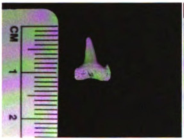

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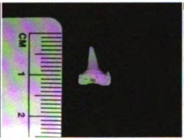

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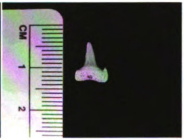

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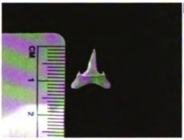

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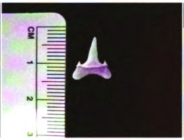

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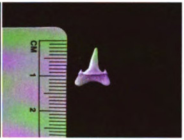

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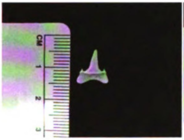

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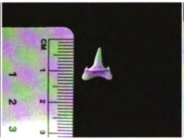

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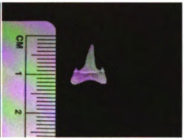

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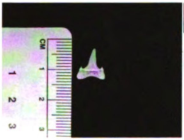

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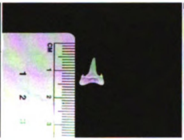

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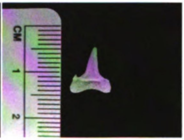

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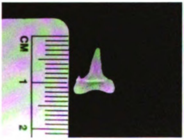

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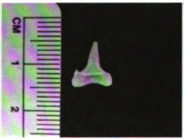

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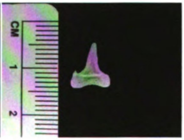

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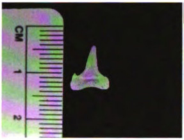

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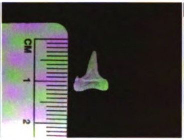

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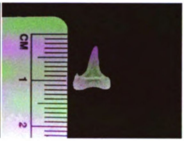

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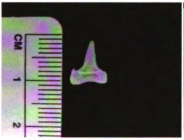

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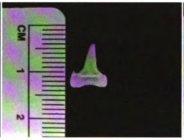

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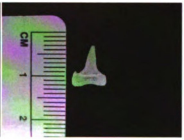

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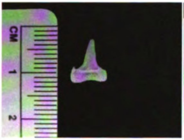

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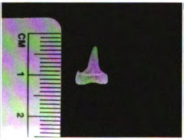

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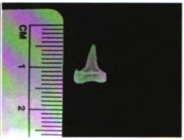

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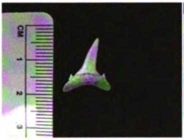
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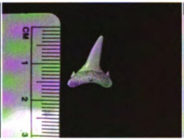
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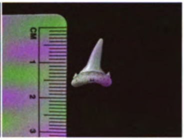
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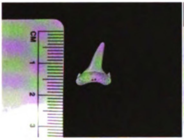
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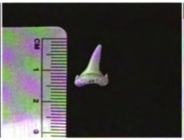
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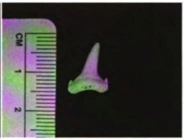
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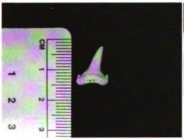
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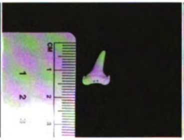
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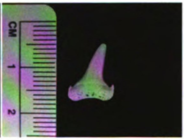
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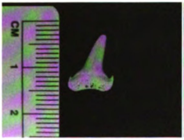
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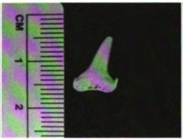
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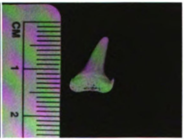
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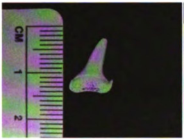

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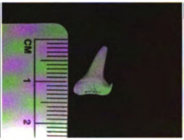

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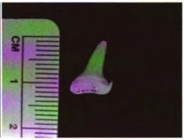

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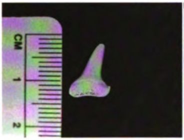

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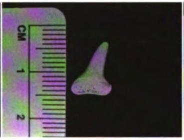

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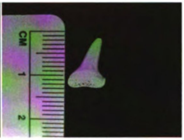

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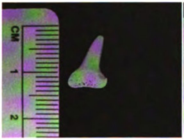

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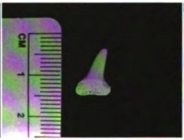

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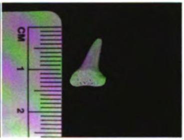

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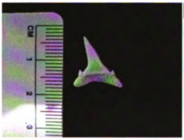
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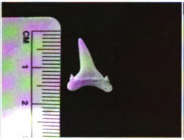
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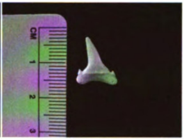
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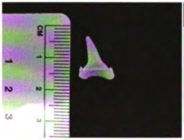
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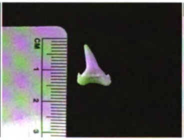
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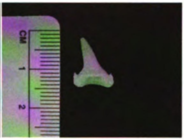
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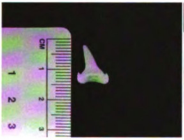
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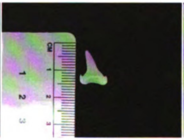
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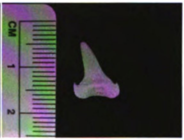
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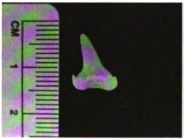
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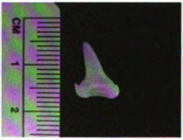
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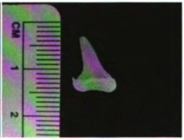
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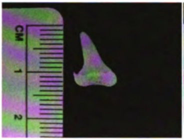
Appendix G continued.



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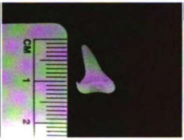

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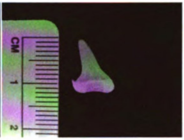

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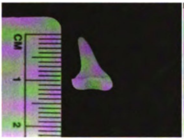

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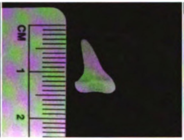

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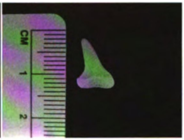

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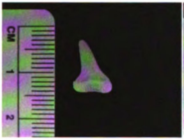

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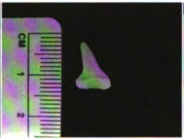

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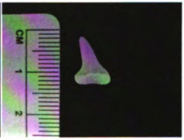


1000H3lab.jpg

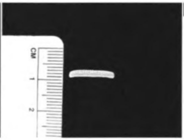
Appendix G continued.

0H4root.jpg

50H4root.jpg

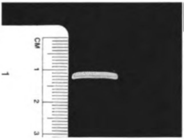
100H4root.jpg

150H4root.jpg



200H4root.jpg

250H4root.jpg



300H4root.jpg

350H4root.jpg

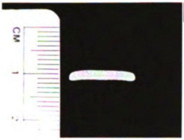
400H4root.jpg

450H4root.jpg

500H4root.jpg

550H4root.jpg

Appendix G continued.



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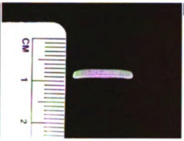

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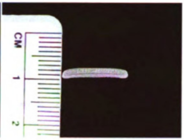

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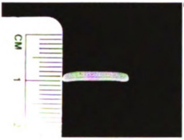

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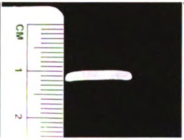

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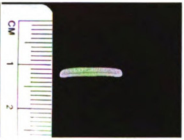

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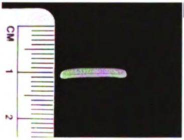

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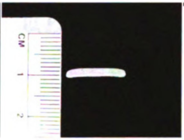

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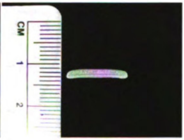

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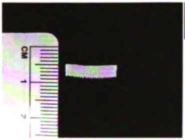
Appendix G continued.



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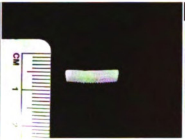

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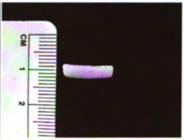

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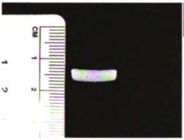

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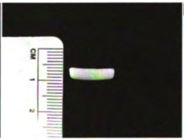

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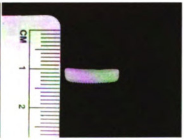

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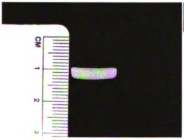

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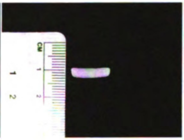

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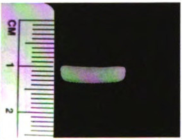

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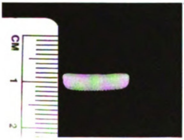

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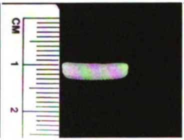

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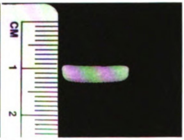

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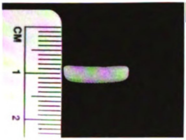
Appendix G continued.



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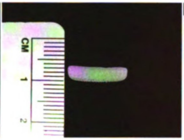

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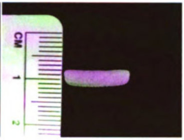

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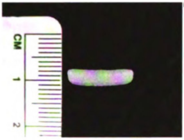

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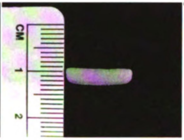

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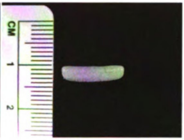

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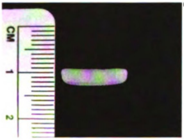

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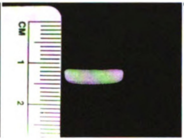

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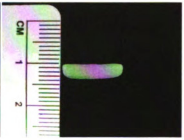


1000H4side.jpg

Appendix G continued.

DIVERSITY, BIOGEOGRAPHY, AND TAPHONOMY OF LATE CRETACEOUS CHONDRICHTHYANS FROM MONTANA

VOLUME III

By

Yasemin Ifakat Tulu

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Geological Sciences

2010

APPENDIX H

DATA FOR TAPHONOMY SERIES

Tooth A1, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	A1	17.52	17.48	17.50	17.49	17.50	17.51	0.0141	17.50
50	A1	17.12	17.11	17.11	17.11	17.10	17.11	0.0063	17.11
100	A1	16.93	16.94	16.93	16.91	16.94	16.93	0.0110	16.93
150	A1	16.69	16.67	16.69	16.66	16.68	16.68	0.0117	16.68
200	A1	16.44	16.45	16.43	16.44	16.44	16.44	0.0063	16.44
250	A1	16.28	16.30	16.26	16.28	16.29	16.29	0.0137	16.28
300	A1	16.25	16.23	16.26	16.16	16.23	16.23	0.0350	16.23
350	A1	16.16	16.15	16.18	16.20	16.17	16.19	0.0187	16.18
400	A1	16.10	16.11	16.13	16.14	16.08	16.12	0.0216	16.11
450	A1	16.06	16.05	16.07	16.07	16.04	16.04	0.0138	16.06
500	A1	15.91	15.93	15.90	15.90	15.90	15.91	0.0117	15.91
550	A1	15.79	15.77	15.80	15.77	15.77	15.77	0.0133	15.78
600	A1	15.62	15.63	15.60	15.60	15.60	15.62	0.0133	15.61
650	A1	15.53	15.55	15.55	15.52	15.54	15.52	0.0138	15.54
700	A1	15.42	15.40	15.41	15.41	15.39	15.39	0.0121	15.40
750	A1	15.35	15.36	15.37	15.36	15.36	15.35	0.0075	15.36
800	A1	15.23	15.23	15.21	15.24	15.24	15.25	0.0137	15.23
850	A1	15.21	15.19	15.22	15.21	15.19	15.21	0.0122	15.21
900	A1	15.18	15.19	15.16	15.16	15.17	15.18	0.0121	15.17
950	A1	15.06	15.05	15.07	15.06	15.06	15.05	0.0075	15.06
1000	A1	14.91	14.89	14.90	14.93	14.92	14.92	0.0147	14.91

Appendix H: Data for taphonomy series.

Tooth A2, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	A2	21.15	21.13	21.14	21.14	21.14	21.13	0.0075	21.14
50	A2	19.29	19.30	19.30	19.29	19.28	19.28	0.0089	19.29
100	A2	18.77	18.76	18.77	18.76	18.75	18.75	0.0089	18.76
150	A2	17.96	17.99	17.96	17.97	17.98	17.98	0.0121	17.97
200	A2	17.36	17.38	17.34	17.34	17.36	17.37	0.0160	17.36
250	A2	17.12	17.12	17.15	17.14	17.14	17.12	0.0133	17.13
300	A2	17.05	17.07	17.07	17.05	17.06	17.06	0.0089	17.06
350	A2	16.94	16.93	16.93	16.93	16.92	16.93	0.0063	16.93
400	A2	16.68	16.68	16.68	16.69	16.68	16.67	0.0063	16.68
450	A2	16.40	16.37	16.37	16.35	16.35	16.38	0.0190	16.37
500	A2	16.10	16.10	16.11	16.11	16.12	16.09	0.0105	16.11
550	A2	15.95	15.95	15.95	15.95	15.95	15.95	0.0000	15.95
600	A2	15.78	15.78	15.77	15.79	15.78	15.78	0.0063	15.78
650	A2	15.67	15.67	15.67	15.67	15.67	15.66	0.0041	15.67
700	A2	15.51	15.51	15.49	15.60	15.51	15.50	0.0400	15.52
750	A2	15.46	15.45	15.44	15.44	15.45	15.44	0.0082	15.45
800	A2	15.35	15.34	15.35	15.35	15.35	15.34	0.0052	15.35
850	A2	15.29	15.29	15.29	15.28	15.29	15.29	0.0041	15.29
900	A2	15.26	15.25	15.25	15.24	15.23	15.24	0.0105	15.25
950	A2	15.20	15.21	15.20	15.21	15.20	15.20	0.0052	15.20
1000	A2	15.13	15.13	15.16	15.18	15.19	15.18	0.0264	15.16

Appendix H continued.

Tooth A3, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	A3	13.83	13.87	13.87	13.81	13.84	13.84	0.0234	13.84
50	A3	12.81	12.82	12.82	12.84	12.83	12.81	0.0117	12.82
100	A3	12.46	12.48	12.49	12.46	12.49	12.47	0.0138	12.48
150	A3	12.12	12.13	12.12	12.13	12.10	12.12	0.0110	12.12
200	A3	11.83	11.85	11.85	11.86	11.86	11.86	0.0117	11.85
250	A3	11.72	11.71	11.69	11.72	11.72	11.72	0.0121	11.71
300	A3	11.64	11.64	11.64	11.64	11.64	11.64	0.0000	11.64
350	A3	11.51	11.51	11.51	11.49	11.47	11.51	0.0167	11.50
400	A3	11.44	11.42	11.42	11.40	11.43	11.43	0.0137	11.42
450	A3	11.37	11.35	11.37	11.36	11.36	11.36	0.0075	11.36
500	A3	11.27	11.27	11.28	11.27	11.28	11.28	0.0055	11.28
550	A3	11.16	11.16	11.16	11.16	11.15	11.15	0.0052	11.16
600	A3	11.05	11.05	11.06	11.05	11.05	11.05	0.0041	11.05
650	A3	10.95	10.96	10.97	10.96	10.96	10.95	0.0075	10.96
700	A3	10.89	10.89	10.88	10.89	10.88	10.89	0.0052	10.89
750	A3	10.83	10.84	10.84	10.84	10.84	10.83	0.0052	10.84
800	A3	10.78	10.78	10.75	10.77	10.77	10.78	0.0117	10.77
850	A3	10.72	10.73	10.73	10.72	10.72	10.72	0.0052	10.72
900	A3	10.68	10.69	10.69	10.68	10.69	10.69	0.0052	10.69
950	A3	10.63	10.61	10.61	10.62	10.63	10.61	0.0098	10.62
1000	A3	10.56	10.54	10.54	10.54	10.55	10.55	0.0082	10.55

Appendix H continued.

Tooth B1, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	B1	8.50	8.48	8.49	8.49	8.49	8.49	0.0063	8.49
50	B1	7.91	7.94	7.92	7.96	7.84	7.84	0.0508	7.90
100	B1	7.75	7.76	7.77	7.75	7.73	7.75	0.0133	7.75
150	B1	7.71	7.72	7.69	7.73	7.71	7.71	0.0133	7.71
200	B1	7.62	7.58	7.58	7.58	7.60	7.60	0.0163	7.59
250	B1	7.46	7.47	7.46	7.45	7.46	7.46	0.0063	7.46
300	B1	7.36	7.36	7.35	7.34	7.37	7.35	0.0105	7.36
350	B1	7.36	7.36	7.35	7.34	7.37	7.35	0.0105	7.36
400	B1	7.30	7.31	7.29	7.30	7.29	7.29	0.0082	7.30
450	B1	7.23	7.21	7.23	7.22	7.24	7.24	0.0117	7.23
500	B1	7.21	7.19	7.20	7.20	7.20	7.20	0.0063	7.20
550	B1	7.12	7.12	7.12	7.12	7.12	7.12	0.0000	7.12
600	B1	7.00	6.98	6.98	6.97	6.97	6.97	0.0117	6.98
650	B1	6.98	6.97	6.96	6.95	6.95	6.96	0.0117	6.96
700	B1	6.91	6.91	6.90	6.90	6.89	6.90	0.0075	6.90
750	B1	6.87	6.87	6.87	6.87	6.87	6.86	0.0041	6.87
800	B1	6.83	6.81	6.82	6.82	6.82	6.82	0.0063	6.82
850	B1	6.77	6.79	6.77	6.78	6.79	6.78	0.0089	6.78
900	B1	6.75	6.75	6.76	6.75	6.76	6.76	0.0055	6.76
950	B1	6.71	6.70	6.70	6.71	6.71	6.71	0.0052	6.71
1000	B1	6.70	6.68	6.69	6.70	6.69	6.68	0.0089	6.69

Appendix H continued.

Tooth B2, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	B2	13.62	13.75	13.70	13.68	13.72	13.69	0.0437	13.69
50	B2	12.67	12.65	12.64	12.56	12.63	12.63	0.0374	12.63
100	B2	12.34	12.33	12.33	12.31	12.32	12.30	0.0147	12.32
150	B2	12.05	12.05	12.04	12.03	12.03	12.02	0.0121	12.04
200	B2	11.76	11.78	11.78	11.74	11.76	11.78	0.0163	11.77
250	B2	11.61	11.62	11.64	11.64	11.63	11.61	0.0138	11.63
300	B2	11.58	11.56	11.57	11.58	11.58	11.58	0.0084	11.58
350	B2	11.44	11.44	11.45	11.44	11.44	11.43	0.0063	11.44
400	B2	11.30	11.31	11.31	11.29	11.29	11.29	0.0098	11.30
450	B2	11.21	11.21	11.20	11.20	11.21	11.20	0.0055	11.21
500	B2	11.10	11.11	11.11	11.11	11.11	11.11	0.0041	11.11
550	B2	10.95	10.95	10.98	10.98	10.97	10.97	0.0137	10.97
600	B2	10.87	10.86	10.87	10.87	10.86	10.87	0.0052	10.87
650	B2	10.77	10.76	10.78	10.77	10.76	10.77	0.0075	10.77
700	B2	10.67	10.67	10.67	10.68	10.69	10.68	0.0082	10.68
750	B2	10.58	10.60	10.60	10.60	10.60	10.59	0.0084	10.60
800	B2	10.48	10.51	10.52	10.52	10.52	10.53	0.0175	10.51
850	B2	10.48	10.48	10.47	10.49	10.47	10.48	0.0075	10.48
900	B2	10.44	10.44	10.42	10.45	10.41	10.44	0.0151	10.43
950	B2	10.40	10.39	10.38	10.37	10.40	10.40	0.0126	10.39
1000	B2	10.35	10.35	10.35	10.36	10.34	10.31	0.0175	10.34

Appendix H continued.

Tooth B3, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	B3	10.61	10.55	10.60	10.55	10.65	10.58	0.0385	10.59
50	B3	9.86	9.90	9.85	9.88	9.86	9.83	0.0242	9.86
100	B3	9.48	9.52	9.50	9.52	9.51	9.54	0.0204	9.51
150	B3	9.26	9.25	9.27	9.25	9.26	9.25	0.0082	9.26
200	B3	9.09	9.08	9.09	9.08	9.08	9.08	0.0052	9.08
250	B3	8.90	8.88	8.87	8.87	8.88	8.88	0.0110	8.88
300	B3	8.74	8.74	8.73	8.73	8.72	8.72	0.0089	8.73
350	B3	8.61	8.60	8.61	8.60	8.61	8.61	0.0052	8.61
400	B3	8.48	8.47	8.47	8.48	8.48	8.49	0.0075	8.48
450	B3	8.39	8.38	8.38	8.38	8.37	8.37	0.0075	8.38
500	B3	8.26	8.27	8.25	8.26	8.26	8.25	0.0075	8.26
550	B3	8.08	8.07	8.09	8.09	8.09	8.08	0.0082	8.08
600	B3	7.98	7.98	7.97	7.97	7.97	7.97	0.0052	7.97
650	B3	7.86	7.87	7.85	7.87	7.88	7.88	0.0117	7.87
700	B3	7.78	7.78	7.80	7.78	7.78	7.76	0.0126	7.78
750	B3	7.69	7.66	7.67	7.66	7.66	7.67	0.0117	7.67
800	B3	7.62	7.61	7.62	7.61	7.60	7.62	0.0082	7.61
850	B3	7.56	7.55	7.55	7.54	7.55	7.56	0.0075	7.55
900	B3	7.51	7.52	7.51	7.54	7.52	7.52	0.0110	7.52
950	B3	7.48	7.49	7.47	7.48	7.48	7.48	0.0063	7.48
1000	B3	7.43	7.41	7.43	7.43	7.44	7.44	0.0110	7.43

Appendix H continued.

Tooth C1, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	C1	15.39	15.46	15.45	15.46	15.43	15.44	0.0264	15.44
50	C1	14.33	14.36	14.27	14.29	14.31	14.36	0.0369	14.32
100	C1	13.97	13.96	13.97	13.96	13.96	13.97	0.0055	13.97
150	C1	13.65	13.65	13.70	13.69	13.65	13.68	0.0228	13.67
200	C1	13.50	13.62	13.53	13.51	13.50	13.50	0.0472	13.53
250	C1	13.35	13.35	13.35	13.35	13.35	13,35	0.0000	13.35
300	C1	13.22	13.22	13.22	13.22	13.22	13.22	0.0000	13.22
350	C1	13.00	12.98	13.02	13.01	13.01	13.02	0.0151	13.01
400	C1	12.92	12.93	12.92	12.92	12.89	12.92	0.0137	12.92
450	C1	12.81	12.79	12.83	12.83	12.83	12.82	0.0160	12.82
500	C1	12.71	12.72	12.71	12.73	12.72	12.73	0.0089	12.72
550	C1	12.62	12.61	12.60	12.60	12.61	12.59	0.0105	12.61
600	C1	12.44	12.44	12.43	12.42	12.42	12.44	0.0098	12.43
650	C1	12.36	12.35	12.38	12.37	12.45	12.37	0.0358	12.38
700	C1	12.28	12.27	12.28	12.26	12.26	12.25	0.0121	12.27
750	C1	12.22	12.21	12.21	12.19	12.19	12.20	0.0121	12.20
800	C1	12.08	12.10	12.09	12.10	12.11	12.10	0.0103	12.10
850	C1	12.04	12.06	12.04	12.03	12.03	12.07	0.0164	12.05
900	C1	12.03	12.05	12.06	12.03	12.07	12.02	0.0197	12.04
950	C1	11.94	11.94	11.97	11.96	11.98	11.98	0.0183	11.96
1000	C1	11.91	11.92	11.95	11.91	11.92	11.95	0.0186	11.93

Appendix H continued.

Tooth C2, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	C2	13.10	12.97	13.03	12.96	12.95	12.99	0.0566	13.00
50	C2	12.11	12.13	12.12	12.14	12.10	12.1	0.0163	12.12
100	C2	11.80	11.77	11.75	11.76	11.80	11.79	0.0214	11.78
150	C2	11.45	11.42	11.43	11.44	11.43	11.43	0.0103	11.43
200	C2	11.36	11.34	11.34	11.32	11.34	11.32	0.0151	11.34
250	C2	11.19	11.15	11.18	11.17	11.18	11.16	0.0147	11.17
300	C2	11.03	11.04	11.05	11.05	11.05	11.06	0.0103	11.05
350	C2	10.94	10.94	10.95	10.95	10.95	10.97	0.0110	10.95
400	C2	10.88	10.87	10.87	10.88	10.88	10.87	0.0055	10.88
450	C2	10.77	10.75	10.75	10.77	10.76	10.77	0.0098	10.76
500	C2	10.69	10.69	10.68	10.68	10.68	10.68	0.0052	10.68
550	C2	10.56	10.54	10.54	10.55	10.54	10.55	0.0082	10.55
600	C2	10.46	10.46	10.46	10.46	10.46	10.46	0.0000	10.46
650	C2	10.36	10.37	10.37	10.38	10.38	10.38	0.0082	10.37
700	C2	10.30	10.29	10.31	10.31	10.29	10.29	0.0098	10.30
750	C2	10.29	10.29	10.27	10.28	10.27	10.26	0.0121	10.28
800	C2	10.23	10.23	10.23	10.23	10.23	10.24	0.0041	10.23
850	C2	10.16	10.15	10.16	10.17	10.18	10.16	0.0103	10.16
900	C2	10.16	10.15	10.16	10.17	10.18	10.16	0.0103	10.16
950	C2	10.11	10.13	10.12	10.13	10.14	10.12	0.0105	10.13
1000	C2	10.10	10.10	10.09	10.09	10.09	10.09	0.0052	10.09

Appendix H continued.

Tooth C3, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	C3	14.76	14.73	14.70	14.68	14.65	14.70	0.0383	14.70
50	C3	13.45	13.40	13.41	13.44	13.42	13.44	0.0197	13.43
100	C3	13.18	13.17	13.16	13.17	13.17	13.17	0.0063	13.17
150	C3	12.99	12.98	12.99	12.97	12.97	12.98	0.0089	12.98
200	C3	12.87	12.86	12.85	12.85	12.88	12.87	0.0121	12.86
250	C3	12.77	12.77	12.76	12.77	12.77	12.77	0.0041	12.77
300	C3	12.68	12.68	12.68	12.68	12.68	12.68	0.0000	12.68
350	C3	12.58	12.58	12.58	12.57	12.59	12.57	0.0075	12.58
400	C3	12.49	12.49	12.49	12.49	12.49	12.49	0.0000	12.49
450	C3	12.42	12.42	12.41	12.40	12.39	12.39	0.0138	12.41
500	C3	12.32	12.33	12.32	12.33	12.33	12.33	0.0052	12.33
550	C3	12.23	12.22	12.22	12.22	12.22	12.23	0.0052	12.22
600	C3	12.16	12.15	12.14	12.15	12.15	12.14	0.0075	12.15
650	C3	12.08	12.08	12.08	12.08	12.08	12.08	0.0000	12.08
700	C3	12.04	12.04	12.04	12.02	12.04	12.04	0.0082	12.04
750	C3	11.98	11.98	11.99	11.99	11.99	11.98	0.0055	11.99
800	C3	11.94	11.93	11.94	11.92	11.92	11.93	0.0089	11.93
850	C3	11.87	11.88	11.89	11.88	11.89	11.89	0.0082	11.88
900	C3	11.85	11.82	11.83	11.83	11.85	11.83	0.0122	11.84
950	C3	11.80	11.81	11.81	11.82	11.81	11.83	0.0103	11.81
1000	C3	11.80	11.81	11.81	11.82	11.81	11.83	0.0103	11.81

Appendix H continued.

Tooth D1, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	D1	13.16	13.32	13.35	13.28	13.27	13.17	0.0778	13.26
50	D1	12.25	12.26	12.26	12.27	12.22	12.24	0.0179	12.25
100	D1	11.71	11.71	11.70	11.72	11.71	11.70	0.0075	11.71
150	D1	11.37	11.37	11.37	11.36	11.35	11.39	0.0133	11.37
200	D1	11.20	11.20	11.19	11.21	11.20	11.20	0.0063	11.20
250	D1	11.10	11.10	11.09	11.10	11.08	11.08	0.0098	11.09
300	D1	11.01	11.01	11.01	11.01	11.01	11.01	0.0000	11.01
350	D1	10.90	10.90	10.89	10.89	10.89	10.89	0.0052	10.89
400	D1	10.79	10.77	10.78	10.78	10.78	10.77	0.0075	10.78
450	D1	10.68	10.68	10.67	10.68	10.68	10.68	0.0041	10.68
500	D1	10.59	10.59	10.59	10.60	10.59	10.59	0.0041	10.59
550	D1	10.48	10.49	10.49	10.49	10.49	10.49	0.0041	10.49
600	D1	10.40	10.41	10.40	10.40	10.40	10.40	0.0041	10.40
650	D1	10.31	10.32	10.31	10.32	10.31	10.32	0.0055	10.32
700	D1	10.26	10.24	10.25	10.24	10.25	10.26	0.0089	10.25
750	D1	10.19	10.19	10.19	10.19	10.18	10.19	0.0041	10.19
800	D1	10.10	10.10	10.09	10.10	10.11	10.11	0.0075	10.10
850	D1	10.07	10.06	10.05	10.05	10.04	10.04	0.0117	10.05
900	D1	9.96	9.99	9.98	9.99	9.98	9.98	0.0110	9.98
950	D1	9.92	9.90	9.90	9.90	9.91	9.91	0.0082	9.91
1000	D1	9.87	9.87	9.86	9.86	9.84	9.83	0.0164	9.86

Appendix H continued.

Tooth D2, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	D2	11.27	11.36	11.35	11.27	11.30	11.29	0.0393	11.31
50	D2	10.24	10.20	10.23	10.25	10.21	10.26	0.0232	10.23
100	D2	9.67	9.67	9.64	9.68	9.68	9.68	0.0155	9.67
150	D2	9.50	9.50	9.51	9.47	9.46	9.48	0.0197	9.49
200	D2	9.32	9.29	9.29	9.30	9.29	9.29	0.0121	9.30
250	D2	9.26	9.24	9.22	9.22	9.23	9.26	0.0183	9.24
300	D2	9.16	9.14	9.17	9.18	9.18	9.17	0.0151	9.17
350	D2	9.07	9.05	9.07	9.05	9.04	9.06	0.0121	9.06
400	D2	8.99	8.99	8.99	8.98	8.98	9.00	0.0075	8.99
450	D2	8.91	8.91	8.89	8.91	8.88	8.88	0.0151	8.90
500	D2	8.83	8.81	8.82	8.83	8.80	8.81	0.0121	8.82
550	D2	8.70	8.69	8.68	8.69	8.71	8.69	0.0103	8.69
600	D2	8.65	8.66	8.66	8.65	8.64	8.64	0.0089	8.65
650	D2	8.58	8.57	8.58	8.59	8.59	8.58	0.0075	8.58
700	D2	8.51	8.49	8.50	8.50	8.49	8.51	0.0089	8.50
750	D2	8.43	8.43	8.43	8.43	8.42	8.42	0.0052	8.43
800	D2	8.37	8.37	8.38	8.39	8.38	8.39	0.0089	8.38
850	D2	8.34	8.34	8.34	8.34	8.34	8.34	0.0000	8.34
900	D2	8.27	8.28	8.27	8.28	8.27	8.26	0.0075	8.27
950	D2	8.24	8.23	8.23	8.23	8.23	8.23	0.0041	8.23
1000	D2	8.19	8.17	8.16	8.18	8.17	8.16	0.0117	8.17

Appendix H continued.

Tooth D3, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	D3	19.39	19.45	19.34	19.42	19.48	19.41	0.0485	19.42
50	D3	17.23	17.22	17.21	17.22	17.21	17.23	0.0089	17.22
100	D3	16.19	16.20	16.19	16.19	16.17	16.16	0.0151	16.18
150	D3	15.68	15.65	15.67	15.66	15.65	15.65	0.0126	15.66
200	D3	15.47	15.45	15.45	15.45	15.45	15.44	0.0098	15.45
250	D3	15.35	15.37	15.35	15.30	15.33	15.36	0.0250	15.34
300	D3	15.27	15.29	15.28	15.29	15.27	15.30	0.0121	15.28
350	D3	15.08	15.09	15.11	15.11	15.08	15.11	0.0151	15.10
400	D3	15.08	15.08	15.08	15.08	15.07	15.06	0.0084	15.08
450	D3	14.92	14.94	14.95	14.91	14.95	14.97	0.0219	14.94
500	D3	14.90	14.87	14.88	14.88	14.89	14.87	0.0117	14.88
550	D3	14.80	14.77	14.78	14.78	14.80	14.80	0.0133	14.79
600	D3	14.76	14.77	14.77	14.76	14.75	14.76	0.0075	14.76
650	D3	14.68	14.69	14.70	14.71	14.71	14.71	0.0126	14.70
700	D3	14.54	15.53	14.52	14.55	14.54	14.53	0.4059	14.70
750	D3	14.54	15.53	14.52	14.55	14.54	14.53	0.4059	14.70
800	D3	14.54	15.53	14.52	14.55	14.54	14.53	0.4059	14.70
850	D3	14.48	14.49	14.47	14.47	14.47	14.47	0.0084	14.48
900	D3	14.48	14.49	14.47	14.47	14.47	14.47	0.0084	14.48
950	D3	14.42	14.43	14.45	14.41	14.41	14.42	0.0151	14.42
1000	D3	14.38	14.41	14.41	14.40	14.42	14.41	0.0138	14.41

Appendix H continued.

Tooth E1, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	E1	15.52	15.61	15.48	15.72	15.67	15.64	0.0911	15.61
50	E1	13.62	13.61	13.61	13.61	13.60	13.63	0.0103	13.61
100	E1	13.26	13.31	13.27	13.31	13.32	13.30	0.0243	13.30
150	E1	13.09	13.08	13.11	13.13	13.11	13.12	0.0186	13.11
200	E1	12.98	13.00	13.00	13.00	12.99	13.00	0.0084	13.00
250	E1	12.88	12.91	12.88	12.86	12.88	12.90	0.0176	12.89
300	E1	12.85	12.85	12.85	12.86	12.86	12.86	0.0055	12.86
350	E1	12.75	12.74	12.74	12.75	12.75	12.75	0.0052	12.75
400	E1	12.69	12.69	12.65	12.66	12.66	12.68	0.0172	12.67
450	E1	12.61	12.58	12.57	12.61	12.59	12.61	0.0176	12.60
500	E1	12.58	12.57	12.56	12.57	12.56	12.58	0.0089	12.57
550	E1	12.38	12.38	12.40	12.41	12.40	12.40	0.0122	12.40
600	E1	12.36	12.37	12.37	12.37	12.36	12.36	0.0055	12.37
650	E1	12.30	12.30	12.30	12.30	12.29	12.29	0.0052	12.30
700	E1	12.23	12.22	12.24	12.23	12.22	12.22	0.0082	12.23
750	E1	12.18	12.19	12.19	12.20	12.19	12.18	0.0075	12.19
800	E1	12.11	12.12	12.13	12.11	12.12	12.11	0.0082	12.12
850	E1	12.07	12.06	12.08	12.07	12.07	12.07	0.0063	12.07
900	E1	11.99	12.02	12.03	12.01	11.99	12.02	0.0167	12.01
950	E1	11.97	12.00	11.99	11.97	11.97	12.00	0.0151	11.98
1000	E1	11.97	12.00	11.99	11.97	11.97	12.00	0.0151	11.98

Appendix H continued.

Tooth E2, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	E2	18.42	18.43	18.38	18.41	18.41	18.41	0.0167	18.41
50	E2	16.32	16.31	16.31	16.31	16.31	16.31	0.0041	16.31
100	E2	15.51	15.50	15.50	15.51	15.52	15.51	0.0075	15.51
150	E2	15.12	15.12	15.13	15.13	15.12	15.13	0.0055	15.13
200	E2	14.84	14.85	14.84	14.85	14.82	14.86	0.0137	14.84
250	E2	14.58	14.57	14.57	14.55	14.55	14.56	0.0121	14.56
300	E2	14.31	14.30	14.31	14.31	14.33	14.32	0.0103	14.31
350	E2	14.15	14.14	14.16	14.14	14.16	14.15	0.0089	14.15
400	E2	13.97	13.98	13.98	13.98	13.98	13.96	0.0084	13.98
450	E2	13.78	13.79	13.79	13.79	13.79	13.79	0.0041	13.79
500	E2	13.66	13.66	13.65	13.64	13.65	13.64	0.0089	13.65
550	E2	13.36	13.34	13.36	13.37	13.36	13.35	0.0103	13.36
600	E2	13.22	13.23	13.23	13.23	13.23	13.21	0.0084	13.23
650	E2	13.08	13.09	13.11	13.10	13.09	13.11	0.0121	13.10
700	E2	12.99	13.01	12.98	12.98	13.00	13.00	0.0121	12.99
750	E2	12.95	12.95	12.95	12.94	12.96	12.95	0.0063	12.95
800	E2	12.88	12.86	12.87	12.89	12.87	12.87	0.0103	12.87
850	E2	12.84	12.85	12.86	12.85	12.86	12.84	0.0089	12.85
900	E2	12.84	12.85	12.82	12.85	12.84	12.84	0.0110	12.84
950	E2	12.79	12.80	12.79	12.80	12.80	12.78	0.0082	12.79
1000	E2	12.79	12.79	12.79	12.79	12.79	12.79	0.0000	12.79

Appendix H continued.

Tooth E3, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	E3	18.49	18.39	18.46	18.48	18.42	18.54	0.0532	18.46
50	E3	16.40	16.40	16.38	16.40	16.37	16.40	0.0133	16.39
100	E3	15.60	15.61	15.59	15.61	15.60	15.62	0.0105	15.61
150	E3	15.34	15.35	15.35	15.36	15.34	15.34	0.0082	15.35
200	E3	15.27	15.25	15.24	15.26	15.24	15.25	0.0117	15.25
250	E3	15.11	15.14	15.12	15.12	15.15	15.15	0.0172	15.13
300	E3	15.02	15.02	15.03	15.04	15.04	15.01	0.0121	15.03
350	E3	14.88	14.89	14.89	14.88	14.89	14.89	0.0052	14.89
400	E3	14.75	14.77	14.77	14.76	14.76	14.75	0.0089	14.76
450	E3	14.61	14.63	14.62	14.62	14.64	14.63	0.0105	14.63
500	E3	14.51	14.53	14.54	14.51	14.53	14.52	0.0121	14.52
550	E3	14.35	14.34	14.33	14.34	14.35	14.34	0.0075	14.34
600	E3	14.21	14.21	14.20	14.20	14.22	14.20	0.0082	14.21
650	E3	14.10	14.10	14.10	14.10	14.11	14.09	0.0063	14.10
700	E3	13.99	14.00	13.98	13.99	14.00	13.99	0.0075	13.99
750	E3	13.91	13.89	13.89	13.90	13.90	13.90	0.0075	13.90
800	E3	13.84	13.84	13.84	13.83	13.83	13.83	0.0055	13.84
850	E3	13.81	13.79	13.81	13.81	13.80	13.80	0.0082	13.80
900	E3	13.73	13.72	13.73	13.70	13.72	13.72	0.0110	13.72
950	E3	13.71	13.72	13.71	13.71	13.71	13.71	0.0041	13.71
1000	E3	13.69	13.70	13.71	13.71	13.71	13.70	0.0082	13.70

Appendix H continued.

Tooth F1, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	F1	10.80	10.81	10.77	10.78	10.78	10.79	0.0147	10.79
50	F1	10.17	10.22	10.21	10.18	10.21	10.19	0.0197	10.20
100	F1	9.85	9.86	9.87	9.87	9.85	9.86	0.0089	9.86
150	F1	9.73	9.73	9.72	9.72	9.71	9.72	0.0075	9.72
200	F1	9.56	9.55	9.56	9.55	9.56	9.55	0.0055	9.56
250	F1	9.47	9.47	9.47	9.46	9.44	9.46	0.0117	9.46
300	F1	9.41	9.42	9.42	9.42	9.42	9.41	0.0052	9.42
350	F1	9.29	9.32	9.30	9.31	9.30	9.30	0.0103	9.30
400	F1	9.21	9.21	9.21	9.22	9.21	9.21	0.0041	9.21
450	F1	9.12	9.13	9.12	9.13	9.12	9.12	0.0052	9.12
500	F1	9.07	9.07	9.07	9.07	9.07	9.06	0.0041	9.07
550	F1	8.93	8.93	8.95	8.96	8.95	8.93	0.0133	8.94
600	F1	8.86	8.90	8.89	8.90	8.89	8.88	0.0151	8.89
650	F1	8.83	8.83	8.85	8.84	8.86	8.85	0.0121	8.84
700	F1	8.81	8.80	8.79	8.80	8.79	8.80	0.0075	8.80
750	F1	8.74	8.74	8.75	8.74	8.74	8.74	0.0041	8.74
800	F1	8.68	8.68	8.69	8.68	8.69	8.69	0.0055	8.69
850	F1	8.64	8.65	8.63	8.64	8.62	8.62	0.0121	8.63
900	F1	8.59	8.60	8.60	8.59	8.59	8.59	0.0052	8.59
950	F1	8.53	8.53	8.54	8.53	8.53	8.54	0.0052	8.53
1000	F1	8.50	8.51	8.51	8.50	8.51	8.51	0.0052	8.51

Appendix H continued.

Tooth F2, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	F2	16.28	16.37	16.34	16.18	16.27	16.28	0.0656	16.29
50	F2	14.86	14.83	14.83	14.83	14.86	14.85	0.0151	14.84
100	F2	14.29	14.30	14.29	14.29	14.27	14.26	0.0151	14.28
150	F2	13.87	13.87	13.86	13.86	13.87	13.85	0.0082	13.86
200	F2	13.74	13.72	13.72	13.74	13.71	13.73	0.0121	13.73
250	F2	13.59	13.60	13.59	13.57	13.60	13.61	0.0137	13.59
300	F2	13.59	13.60	13.59	13.57	13.60	13.61	0.0137	13.59
350	F2	13.42	13.42	13.40	13.44	13.41	13.41	0.0137	13.42
400	F2	13.29	13.30	13.31	13.29	13.29	13.29	0.0084	13.30
450	F2	13.21	13.20	13.20	13.18	13.19	13.18	0.0121	13.19
500	F2	13.09	13.06	13.08	13.08	13.08	13.07	0.0103	13.08
550	F2	12.99	12.99	13.00	13.00	12.99	13.00	0.0055	13.00
600	F2	12.93	12.92	12.93	12.93	12.92	12.92	0.0055	12.93
650	F2	12.86	12.87	12.86	12.84	12.83	12.82	0.0197	12.85
700	F2	12.80	12.80	12.81	12.81	12.82	12.82	0.0089	12.81
750	F2	12.75	12.76	12.76	12.76	12.76	12.75	0.0052	12.76
800	F2	12.67	12.68	12.67	12.67	12.66	12.67	0.0063	12.67
850	F2	12.58	12.57	12.58	12.59	12.58	12.60	0.0103	12.58
900	F2	12.58	12.57	12.58	12.59	12.58	12.60	0.0103	12.58
950	F2	12.55	12.54	12.55	12.55	12.55	12.55	0.0041	12.55
1000	F2	12.54	12.53	12.52	12.53	12.52	12.51	0.0105	12.53

Appendix H continued.

Tooth F3, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	F3	12.35	12.29	12.15	12.27	12.23	12.23	0.0674	12.25
50	F3	11.57	11.61	11.58	11.59	11.57	11.59	0.0152	11.59
100	F3	11.19	11.19	11.18	11.24	11.23	11.26	0.0327	11.22
150	F3	11.00	11.01	11.02	11.00	11.02	10.99	0.0121	11.01
200	F3	10.93	10.94	10.96	10.95	10.93	10.93	0.0126	10.94
250	F3	10.84	10.86	10.85	10.86	10.86	10.86	0.0084	10.86
300	F3	10.84	10.86	10.85	10.86	10.86	10.86	0.0084	10.86
350	F3	10.77	10.75	10.78	10.77	10.76	10.76	0.0105	10.77
400	F3	10.71	10.71	10.72	10.71	10.71	10.70	0.0063	10.71
450	F3	10.61	10.63	10.61	10.62	10.61	10.60	0.0103	10.61
500	F3	10.57	10.56	10.59	10.59	10.59	10.60	0.0151	10.58
550	F3	10.54	10.52	10.54	10.54	10.54	10.52	0.0103	10.53
600	F3	10.40	10.42	10.42	10.43	10.43	10.42	0.0110	10.42
650	F3	10.40	10.41	10.39	10.39	10.41	10.40	0.0089	10.40
700	F3	10.34	10.35	10.36	10.36	10.38	10.38	0.0160	10.36
750	F3	10.32	10.33	10.33	10.33	10.34	10.32	0.0075	10.33
800	F3	10.24	10.26	10.26	10.27	10.25	10.26	0.0103	10.26
850	F3	10.17	10.16	10.17	10.16	10.15	10.16	0.0075	10.16
900	F3	10.17	10.16	10.17	10.16	10.15	10.16	0.0075	10.16
950	F3	10.11	10.13	10.13	10.13	10.13	10.13	0.0082	10.13
1000	F3	10.08	10.09	10.08	10.09	10.08	10.07	0.0075	10.08

Appendix H continued.

Tooth G1, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	G1	12.95	12.97	13.02	12.90	12.99	12.97	0.0403	12.97
50	G1	12.07	12.06	12.06	12.06	12.05	12.06	0.0063	12.06
100	G1	11.84	11.82	11.83	11.81	11.81	11.82	0.0117	11.82
150	G1	11.67	11.68	11.70	11.70	11.70	11.69	0.0126	11.69
200	G1	11.60	11.59	11.60	11.58	11.59	11.58	0.0089	11.59
250	G1	11.42	11.43	11.42	11.41	11.42	11.42	0.0063	11.42
300	G1	11.32	11.32	11.32	11.32	11.32	11.32	0.0000	11.32
350	G1	11.23	11.23	11.22	11.22	11.22	11.22	0.0052	11.22
400	G1	11.11	11.11	11.11	11.11	11.11	11.11	0.0000	11.11
450	G1	11.03	11.03	11.03	11.03	11.03	11.03	0.0000	11.03
500	G1	10.97	10.96	10.97	10.96	10.96	10.95	0.0075	10.96
550	G1	10.82	10.83	10.83	10.83	10.84	10.83	0.0063	10.83
600	G1	10.75	10.77	10.76	10.77	10.75	10.75	0.0098	10.76
650	G1	10.73	10.73	10.72	10.72	10.72	10.73	0.0055	10.73
700	G1	10.67	10.66	10.65	10.66	10.64	10.65	0.0105	10.66
750	G1	10.59	10.59	10.58	10.60	10.58	10.59	0.0075	10.59
800	G1	10.52	10.54	10.53	10.54	10.53	10.53	0.0075	10.53
850	G1	10.51	10.51	10.50	10.52	10.50	10.51	0.0075	10.51
900	G1	10.48	10.47	10.48	10.48	10.48	10.51	0.0137	10.48
950	G1	10.42	10.43	10.42	10.43	10.44	10.43	0.0075	10.43
1000	G1	10.42	10.42	10.41	10.41	10.42	10.41	0.0055	10.42

Appendix H continued.

Tooth G2, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	G2	15.11	15.03	15.10	15.13	15.07	15.13	0.0389	15.10
50	G2	13.87	13.86	13.85	13.85	13.85	13.87	0.0098	13.86
100	G2	13.29	13.29	13.29	13.28	13.29	13.27	0.0084	13.29
150	G2	12.88	12.89	12.89	12.85	12.90	12.90	0.0187	12.89
200	G2	12.60	12.63	12.61	12.62	12.63	12.63	0.0126	12.62
250	G2	12.39	12.40	12.39	12.38	12.39	12.37	0.0103	12.39
300	G2	12.18	12.17	12.18	12.18	12.17	12.18	0.0052	12.18
350	G2	11.96	11.97	12.00	11.98	11.99	11.96	0.0163	11.98
400	G2	11.87	11.85	11.85	11.84	11.85	11.84	0.0110	11.85
450	G2	11.72	11.72	11.73	11.73	11.72	11.72	0.0052	11.72
500	G2	11.60	11.61	11.60	11.60	11.60	11.60	0.0041	11.60
550	G2	11.45	11.45	11.43	11.43	11.44	11.45	0.0098	11.44
600	G2	11.34	11.35	11.34	11.34	11.34	11.34	0.0041	11.34
650	G2	11.25	11.27	11.27	11.25	11.26	11.25	0.0098	11.26
700	G2	11.16	11.15	11.15	11.15	11.15	11.15	0.0041	11.15
750	G2	10.91	10.91	10.91	10.91	10.91	10.91	0.0000	10.91
800	G2	11.05	11.04	11.03	11.02	11.02	11.02	0.0126	11.03
850	G2	10.81	10.82	10.82	10.81	10.81	10.81	0.0052	10.81
900	G2	10.77	10.78	10.77	10.79	10.76	10.77	0.0103	10.77
950	G2	10.72	10.71	10.70	10.72	10.72	10.72	0.0084	10.72
1000	G2	10.61	10.58	10.59	10.59	10.62	10.62	0.0172	10.60

Appendix H continued.

Tooth G3, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	G3	14.85	14.80	14.68	14.81	14.78	14.78	0.0568	14.78
50	G3	13.90	13.87	13.90	13.89	13.91	13.89	0.0137	13.89
100	G3	13.46	13.45	13.47	13.46	13.46	13.46	0.0063	13.46
150	G3	13.11	13.11	13.10	13.10	13.22	13.14	0.0465	13.13
200	G3	12.87	12.89	12.85	12.86	12.87	12.87	0.0133	12.87
250	G3	12.67	12.65	12.65	12.68	12.68	12.68	0.0147	12.67
300	G3	12.50	12.50	12.52	12.51	12.51	12.52	0.0089	12.51
350	G3	12.38	12.39	12.38	12.39	12.37	12.39	0.0082	12.38
400	G3	12.25	12.26	12.25	12.25	12.26	12.24	0.0075	12.25
450	G3	12.12	12.11	12.10	12.12	12.11	12.11	0.0075	12.11
500	G3	11.96	11.97	11.96	11.98	11.96	11.97	0.0082	11.97
550	G3	11.81	11.82	11.82	11.83	11.82	11.82	0.0063	11.82
600	G3	11.73	11.74	11.73	11.74	11.75	11.74	0.0075	11.74
650	G3	11.64	11.65	11.64	11.65	11.65	11.65	0.0052	11.65
700	G3	11.55	11.56	11.56	11.56	11.57	11.57	0.0075	11.56
750	G3	11.47	11.47	11.48	11.47	11.48	11.47	0.0052	11.47
800	G3	11.39	11.40	11.40	11.40	11.41	11.40	0.0063	11.40
850	G3	11.35	11.35	11.36	11.35	11.35	11.35	0.0041	11.35
900	G3	11.31	11.30	11.31	11.30	11.31	11.31	0.0052	11.31
950	G3	11.28	11.27	11.26	11.26	11.27	11.26	0.0082	11.27
1000	G3	11.24	11.24	11.23	11.23	11.24	11.24	0.0052	11.24

Appendix H continued.

Tooth H1, Height in mm										
		1	2	3	4	5	6	ST DEV	Average
0	H1	12.31	12.29	12.29	12.28	12.22	12.22	0.0387	12.27
50	H1	11.03	11.03	11.05	11.02	11.03	11.04	0.0103	11.03
100	H1	10.63	10.63	10.65	10.62	10.62	10.64	0.0117	10.63
150	H1	10.45	10.44	10.43	10.44	10.43	10.44	0.0075	10.44
200	H1	10.31	10.31	10.32	10.32	10.31	10.31	0.0052	10.31
250	H1	10.23	10.22	10.22	10.22	10.24	10.23	0.0082	10.23
300	H1	10.18	10.16	10.18	10.16	10.18	10.16	0.0110	10.17
350	H1	10.05	10.06	10.06	10.05	10.07	10.06	0.0075	10.06
400	H1	9.94	9.94	9.94	9.94	9.94	9.95	0.0041	9.94
450	H1	9.84	9.84	9.83	9.82	9.83	9.82	0.0089	9.83
500	H1	9.72	9.71	9.72	9.72	9.72	9.72	0.0041	9.72
550	H1	9.63	9.63	9.63	9.63	9.63	9.63	0.0000	9.63
600	H1	9.58	9.59	9.58	9.58	9.57	9.57	0.0075	9.58
650	H1	9.54	9.54	9.53	9.52	9.53	9.52	0.0089	9.53
700	H1	9.50	9.50	9.49	9.48	9.48	9.49	0.0089	9.49
750	H1	9.42	9.43	9.43	9.44	9.43	9.44	0.0075	9.43
800	H1	9.40	9.39	9.40	9.39	9.38	9.38	0.0089	9.39
850	H1	9.34	9.32	9.34	9.32	9.33	9.33	0.0089	9.33
900	H1	9.28	9.28	9.28	9.28	9.28	9.28	0.0000	9.28
950	H1	9.25	9.24	9.22	9.24	9.24	9.23	0.0103	9.24
1000	H1	9.20	9.21	9.21	9.21	9.21	9.23	0.0098	9.21

Appendix H continued.

Tooth H2, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	H2	11.63	11.62	11.69	11.83	11.84	11.68	0.0969	11.72
50	H2	11.22	11.23	11.22	11.20	11.21	11.22	0.0103	11.22
100	H2	10.88	10.93	10.90	10.94	10.91	10.94	0.0242	10.92
150	H2	10.59	10.61	10.63	10.64	10.59	10.59	0.0223	10.61
200	H2	10.52	10.53	10.53	10.53	10.55	10.56	0.0151	10.54
250	H2	10.42	10.43	10.41	10.40	10.40	10.42	0.0121	10.41
300	H2	10.30	10.33	10.33	10.32	10.33	10.32	0.0117	10.32
350	H2	10.19	10.21	10.18	10.18	10.18	10.18	0.0121	10.19
400	H2	9.99	9.99	10.01	10.02	10.02	10.01	0.0137	10.01
450	H2	9.81	9.82	9.83	9.83	9.83	9.81	0.0098	9.82
500	H2	9.77	9.76	9.76	9.77	9.75	9.77	0.0082	9.76
550	H2	9.64	9.61	9.63	9.62	9.63	9.61	0.0121	9.62
600	H2	9.60	9.60	9.61	9.59	9.58	9.57	0.0147	9.59
650	H2	9.52	9.54	9.53	9.54	9.54	9.55	0.0103	9.54
700	H2	9.49	9.49	9.50	9.49	9.48	9.49	0.0063	9.49
750	H2	9.44	9.42	9.42	9.43	9.42	9.42	0.0084	9.43
800	H2	9.35	9.37	9.36	9.34	9.36	9.34	0.0121	9.35
850	H2	9.26	9.26	9.28	9.27	9.27	9.28	0.0089	9.27
900	H2	9.22	9.21	9.21	9.22	9.21	9.22	0.0055	9.22
950	H2	9.20	9.20	9.20	9.20	9.19	9.19	0.0052	9.20
1000	H2	9.17	9.16	9.16	9.16	9.16	9.16	0.0041	9.16

Appendix H continued.

Tooth H3, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	H3	15.22	15.19	15.20	15.19	15.16	15.12	0.0352	15.18
50	H3	14.07	14.06	14.04	14.04	14.06	14.04	0.0133	14.05
100	H3	13.57	13.57	13.58	13.58	13.58	13.57	0.0055	13.58
150	H3	13.22	13.24	13.23	13.20	13.20	13.30	0.0371	13.23
200	H3	13.00	13.00	13.05	13.05	13.02	13.02	0.0225	13.02
250	H3	12.84	12.83	12.82	12.85	12.84	12.84	0.0103	12.84
300	H3	12.78	12.77	12.78	12.78	12.77	12.78	0.0052	12.78
350	H3	12.52	12.51	12.52	12.52	12.51	12.52	0.0052	12.52
400	H3	12.30	12.29	12.29	12.28	12.28	12.28	0.0082	12.29
450	H3	12.09	12.07	12.09	12.09	12.08	12.07	0.0098	12.08
500	H3	11.92	11.92	11.93	11.93	11.92	11.93	0.0055	11.93
550	H3	11.74	11.73	11.75	11.77	11.77	11.78	0.0197	11.76
600	H3	11.65	11.66	11.67	11.67	11.66	11.67	0.0082	11.66
650	H3	11.59	11.60	11.61	11.59	11.59	11.60	0.0082	11.60
700	H3	11.54	11.53	11.53	11.54	11.53	11.54	0.0055	11.54
750	H3	11.44	11.45	11.46	11.44	11.45	11.44	0.0082	11.45
800	H3	11.35	11.38	11.37	11.38	11.39	11.38	0.0138	11.38
850	H3	11.29	11.30	11.30	11.31	11.29	11.29	0.0082	11.30
900	H3	11.25	11.25	11.24	11.24	11.25	11.24	0.0055	11.25
950	H3	11.19	11.21	11.22	11.20	11.22	11.20	0.0121	11.21
1000	H3	11.14	11.14	11.20	11.20	11.18	11.19	0.0281	11.18

Appendix H continued.

Tooth A4, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	A4	3.60	3.65	3.39	3.42	3.43	3.50	0.1057	3.50
50	A4	3.43	3.49	3.49	3.49	3.49	3.50	0.0256	3.48
100	A4	3.48	3.48	3.49	3.50	3.48	3.49	0.0082	3.49
150	A4	3.31	3.31	3.30	3.29	3.30	3.31	0.0082	3.30
200	A4	3.31	3.31	3.30	3.29	3.30	3.31	0.0082	3.30
250	A4	3.30	3.29	3.29	3.28	3.30	3.31	0.0105	3.30
300	A4	3.31	3.29	3.29	3.28	3.29	3.29	0.0098	3.29
350	A4	3.31	3.29	3.29	3.28	3.29	3.29	0.0098	3.29
400	A4	3.31	3.29	3.29	3.28	3.29	3.29	0.0098	3.29
450	A4	3.31	3.29	3.29	3.28	3.29	3.29	0.0098	3.29
500	A4	3.31	3.29	3.29	3.28	3.29	3.29	0.0098	3.29
550	A4	3.31	3.29	3.29	3.28	3.29	3.29	0.0098	3.29
600	A4	3.31	3.29	3.29	3.28	3.29	3.29	0.0098	3.29
650	A4	3.31	3.29	3.29	3.28	3.29	3.29	0.0098	3.29
700	A4	3.31	3.29	3.29	3.28	3.29	3.29	0.0098	3.29
750	A4	3.25	3.27	3.28	3.27	3.26	3.27	0.0103	3.27
800	A4	3.25	3.27	3.28	3.27	3.26	3.27	0.0103	3.27
850	A4	3.25	3.27	3.28	3.27	3.26	3.27	0.0103	3.27
900	A4	3.25	3.27	3.28	3.27	3.26	3.27	0.0103	3.27
950	A4	3.25	3.27	3.28	3.27	3.26	3.27	0.0103	3.27
1000	A4	3.25	3.27	3.28	3.27	3.26	3.27	0.0103	3.27

Appendix H continued.

Tooth B4, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	B4	3.46	3.53	3.58	3.58	3.44	3.53	0.0590	3.52
50	B4	3.21	3.22	3.23	3.22	3.22	3.22	0.0063	3.22
100	B4	3.20	3.21	3.22	3.20	3.20	3.20	0.0084	3.21
150	B4	3.19	3.19	3.18	3.18	3.18	3.17	0.0075	3.18
200	B4	3.16	3.16	3.14	3.14	3.17	3.15	0.0121	3.15
250	B4	3.07	3.06	3.07	3.05	3.06	3.04	0.0117	3.06
300	B4	3.07	3.06	3.07	3.05	3.06	3.04	0.0117	3.06
350	B4	3.07	3.06	3.07	3.05	3.06	3.04	0.0117	3.06
400	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01
450	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01
500	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01
550	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01
600	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01
650	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01
700	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01
750	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01
800	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01
850	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01
900	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01
950	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01
1000	B4	3.00	3.01	3.02	3.01	3.01	3.01	0.0063	3.01

Appendix H continued.

Tooth C4, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	C4	3.29	3.27	3.28	3.27	3.28	3.28	0.0075	3.28
50	C4	3.25	3.28	3.26	3.26	3.27	3.26	0.0103	3.26
100	C4	3.17	3.17	3.17	3.19	3.18	3.20	0.0126	3.18
150	C4	3.15	3.16	3.14	3.15	3.16	3.14	0.0089	3.15
200	C4	3.15	3.16	3.14	3.15	3.16	3.14	0.0089	3.15
250	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
300	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
350	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
400	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
450	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
500	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
550	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
600	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
650	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
700	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
750	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
800	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
850	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
900	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
950	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05
1000	C4	3.06	3.05	3.05	3.06	3.06	3.04	0.0082	3.05

Appendix H continued.

Tooth D4, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	D4	2.96	2.91	2.88	2.88	2.88	2.90	0.0313	2.90
50	D4	2.85	2.81	2.80	2.80	2.80	2.79	0.0214	2.81
100	D4	2.73	2.73	2.72	2.73	2.72	2.73	0.0052	2.73
150	D4	2.69	2.70	2.69	2.69	2.69	2.73	0.0160	2.70
200	D4	2.69	2.70	2.69	2.69	2.69	2.73	0.0160	2.70
250	D4	2.66	2.66	2.67	2.66	2.66	2.67	0.0052	2.66
300	D4	2.66	2.66	2.67	2.66	2.66	2.67	0.0052	2.66
350	D4	2.66	2.66	2.67	2.66	2.66	2.67	0.0052	2.66
400	D4	2.66	2.66	2.67	2.66	2.66	2.67	0.0052	2.66
450	D4	2.63	2.63	2.65	2.59	2.64	2.60	0.0234	2.62
500	D4	2.63	2.63	2.65	2.59	2.64	2.60	0.0234	2.62
550	D4	2.63	2.63	2.65	2.59	2.64	2.60	0.0234	2.62
600	D4	2.63	2.63	2.65	2.59	2.64	2.60	0.0234	2.62
650	D4	2.63	2.63	2.65	2.59	2.64	2.60	0.0234	2.62
700	D4	2.63	2.63	2.65	2.59	2.64	2.60	0.0234	2.62
750	D4	2.55	2.57	2.55	2.54	2.56	2.54	0.0117	2.55
800	D4	2.55	2.57	2.55	2.54	2.56	2.54	0.0117	2.55
850	D4	2.55	2.57	2.55	2.54	2.56	2.54	0.0117	2.55
900	D4	2.55	2.57	2.55	2.54	2.56	2.54	0.0117	2.55
950	D4	2.53	2.54	2.52	2.53	2.54	2.55	0.0105	2.54
1000	D4	2.53	2.54	2.52	2.53	2.54	2.55	0.0105	2.54

Appendix H continued.

Tooth E4, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	E4	2.99	3.03	3.08	3.03	3.04	3.03	0.0288	3.03
50	E4	2.91	2.96	2.92	2.94	2.91	2.91	0.0207	2.93
100	E4	2.89	2.90	2.90	2.89	2.89	2.89	0.0052	2.89
150	E4	2.87	2.88	2.86	2.87	2.87	2.87	0.0063	2.87
200	E4	2.87	2.88	2.86	2.87	2.87	2.87	0.0063	2.87
250	E4	2.81	2.83	2.83	2.83	2.82	2.83	0.0084	2.83
300	E4	2.81	2.83	2.83	2.83	2.82	2.83	0.0084	2.83
350	E4	2.81	2.83	2.83	2.83	2.82	2.83	0.0084	2.83
400	E4	2.81	2.83	2.83	2.83	2.82	2.83	0.0084	2.83
450	E4	2.78	2.77	2.77	2.76	2.77	2.77	0.0063	2.77
500	E4	2.78	2.77	2.77	2.76	2.77	2.77	0.0063	2.77
550	E4	2.78	2.77	2.77	2.76	2.77	2.77	0.0063	2.77
600	E4	2.78	2.77	2.77	2.76	2.77	2.77	0.0063	2.77
650	E4	2.78	2.77	2.77	2.76	2.77	2.77	0.0063	2.77
700	E4	2.78	2.77	2.77	2.76	2.77	2.77	0.0063	2.77
750	E4	2.78	2.77	2.77	2.76	2.77	2.77	0.0063	2.77
800	E4	2.78	2.77	2.77	2.76	2.77	2.77	0.0063	2.77
850	E4	2.78	2.77	2.77	2.76	2.77	2.77	0.0063	2.77
900	E4	2.78	2.77	2.77	2.76	2.77	2.77	0.0063	2.77
950	E4	2.70	2.70	2.69	2.69	2.70	2.70	0.0052	2.70
1000	E4	2.70	2.70	2.69	2.69	2.70	2.70	0.0052	2.70

Appendix H continued.

Tooth F4, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	F4	2.38	2.35	2.35	2.35	2.33	2.36	0.0163	2.35
50	F4	2.30	2.29	2.28	2.28	2.29	2.28	0.0082	2.29
100	F4	2.25	2.25	2.26	2.26	2.25	2.25	0.0052	2.25
150	F4	2.23	2.21	2.22	2.23	2.20	2.20	0.0138	2.22
200	F4	2.22	2.22	2.22	2.22	2.22	2.22	0.0000	2.22
250	F4	2.20	2.20	2.19	2.19	2.20	2.20	0.0052	2.20
300	F4	2.20	2.20	2.19	2.19	2.20	2.20	0.0052	2.20
350	F4	2.20	2.20	2.19	2.19	2.20	2.20	0.0052	2.20
400	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14
450	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14
500	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14
550	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14
600	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14
650	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14
700	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14
750	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14
800	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14
850	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14
900	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14
950	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14
1000	F4	2.15	2.14	2.13	2.14	2.15	2.14	0.0075	2.14

Appendix H continued.

Tooth G4, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	G4	1.71	1.74	1.71	1.71	1.75	1.73	0.0176	1.73
50	G4	1.63	1.64	1.64	1.63	1.63	1.65	0.0082	1.64
100	G4	1.58	1.57	1.60	1.61	1.58	1.57	0.0164	1.59
150	G4	1.56	1.58	1.57	1.57	1.57	1.57	0.0063	1.57
200	G4	1.56	1.57	1.57	1.56	1.57	1.56	0.0055	1.57
250	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
300	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
350	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
400	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
450	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
500	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
550	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
600	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
650	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
700	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
750	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
800	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
850	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
900	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
950	G4	1.53	1.54	1.54	1.53	1.54	1.54	0.0052	1.54
1000	G4	1.52	1.52	1.51	1.52	1.52	1.52	0.0041	1.52

Appendix H continued.

Tooth H4, Height in mm									
		1	2	3	4	5	6	ST DEV	Average
0	H4	3.57	3.56	3.57	3.57	3.56	3.56	0.0055	3.57
50	H4	3.48	3.49	3.48	3.49	3.48	3.49	0.0055	3.49
100	H4	3.36	3.37	3.42	3.37	3.37	3.37	0.0216	3.38
150	H4	3.34	3.35	3.34	3.35	3.34	3.33	0.0075	3.34
200	H4	3.34	3.33	3.34	3.33	3.34	3.33	0.0055	3.34
250	H4	3.30	3.30	3.30	3.30	3.30	3.30	0.0000	3.30
300	H4	3.30	3.30	3.30	3.30	3.30	3.30	0.0000	3.30
350	H4	3.30	3.30	3.30	3.30	3.30	3.30	0.0000	3.30
400	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25
450	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25
500	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25
550	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25
600	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25
650	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25
700	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25
750	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25
800	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25
850	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25
900	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25
950	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25
1000	H4	3.24	3.24	3.25	3.26	3.26	3.25	0.0089	3.25

Appendix H continued.

Tooth A1, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	A1	8.51	8.49	8.55	8.54	8.51	8.53	0.0223	8.52
50	A1	8.41	8.34	8.34	8.33	8.38	8.39	0.0327	8.37
100	A1	8.28	8.26	8.23	8.24	8.25	8.26	0.0175	8.25
150	A1	8.21	8.19	8.22	8.22	8.20	8.20	0.0121	8.21
200	A1	8.09	8.10	8.10	8.08	8.09	8.09	0.0075	8.09
250	A1	8.04	8.06	8.05	8.04	8.01	8.03	0.0172	8.04
300	A1	8.04	8.06	8.05	8.04	8.01	8.03	0.0172	8.04
350	A1	8.02	8.03	8.05	8.06	8.04	8.01	0.0187	8.04
400	A1	7.93	7.94	7.93	7.95	7.95	7.92	0.0121	7.94
450	A1	7.86	7.88	7.88	7.87	7.89	7.84	0.0179	7.87
500	A1	7.79	7.78	7.80	7.78	7.77	7.78	0.0103	7.78
550	A1	7.79	7.78	7.80	7.78	7.77	7.78	0.0103	7.78
600	A1	7.79	7.78	7.80	7.78	7.77	7.78	0.0103	7.78
650	A1	7.79	7.78	7.80	7.78	7.77	7.78	0.0103	7.78
700	A1	7.74	7.74	7.71	7.73	7.72	7.73	0.0117	7.73
750	A1	7.67	7.69	7.67	7.66	7.67	7.66	0.0110	7.67
800	A1	7.64	7.62	7.64	7.60	7.63	7.62	0.0152	7.63
850	A1	7.46	7.44	7.45	7.48	7.46	7.48	0.0160	7.46
900	A1	7.39	7.42	7.40	7.41	7.41	7.40	0.0105	7.41
950	A1	7.32	7.35	7.33	7.33	7.31	7.31	0.0152	7.33
1000	A1	7.32	7.35	7.33	7.33	7.31	7.31	0.0152	7.33

Appendix H continued.

Tooth A2, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	A2	13.52	13.51	13.56	13.54	13.54	13.52	0.0183	13.53
50	A2	11.63	11.62	11.62	11.62	11.57	11.61	0.0214	11.61
100	A2	11.02	11.03	11.03	11.03	11.02	11.03	0.0052	11.03
150	A2	10.32	10.34	10.32	10.34	10.33	10.33	0.0089	10.33
200	A2	9.83	9.81	9.83	9.79	9.79	9.81	0.0179	9.81
250	A2	9.62	9.64	9.64	9.63	9.63	9.63	0.0075	9.63
300	A2	9.53	9.53	9.51	9.50	9.52	9.51	0.0121	9.52
350	A2	9.26	9.25	9.25	9.25	9.29	9.30	0.0225	9.27
400	A2	8.96	8.97	8.97	8.96	8.95	8.96	0.0075	8.96
450	A2	8.65	8.64	8.62	8.63	8.65	8.63	0.0121	8.64
500	A2	8.43	8.41	8.40	8.38	8.39	8.39	0.0179	8.40
550	A2	8.22	8.23	8.23	8.22	8.22	8.22	0.0052	8.22
600	A2	8.03	8.01	8.01	8.00	8.02	8.01	0.0103	8.01
650	A2	7.87	7.85	7.84	7.85	7.86	7.88	0.0147	7.86
700	A2	7.70	7.70	7.70	7.70	7.70	7.69	0.0041	7.70
750	A2	7.58	7.57	7.57	7.58	7.57	7.57	0.0052	7.57
800	A2	7.50	7.50	7.49	7.51	7.49	7.49	0.0082	7.50
850	A2	7.43	7.43	7.42	7.41	7.41	7.42	0.0089	7.42
900	A2	7.39	7.39	7.39	7.39	7.38	7.38	0.0052	7.39
950	A2	7.30	7.31	7.30	7.32	7.32	7.33	0.0121	7.31
1000	A2	7.31	7.31	7.27	7.27	7.29	7.28	0.0183	7.29

Appendix H continued.

Tooth A3, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	A3	12.72	12.67	12.66	12.66	12.67	12.67	0.0226	12.68
50	A3	10.68	10.68	10.68	10.67	10.68	10.67	0.0052	10.68
100	A3	10.29	10.27	10.26	10.26	10.26	10.26	0.0121	10.27
150	A3	9.85	9.83	9.81	9.80	9.80	9.83	0.0200	9.82
200	A3	9.50	9.48	9.48	9.47	9.47	9.46	0.0137	9.48
250	A3	9.24	9.25	9.26	9.26	9.26	9.28	0.0133	9.26
300	A3	9.18	9.16	9.14	9.14	9.18	9.16	0.0179	9.16
350	A3	9.08	9.08	9.07	9.05	9.05	9.05	0.0151	9.06
400	A3	8.90	8.91	8.89	8.89	8.88	8.88	0.0117	8.89
450	A3	8.78	8.79	8.80	8.81	8.79	8.78	0.0117	8.79
500	A3	8.68	8.67	8.66	8.65	8.65	8.66	0.0117	8.66
550	A3	8.52	8.53	8.51	8.51	8.52	8.50	0.0105	8.52
600	A3	8.39	8.40	8.40	8.41	8.41	8.43	0.0137	8.41
650	A3	8.24	8.26	8.22	8.23	8.23	8.23	0.0138	8.24
700	A3	8.34	8.34	8.32	8.33	8.34	8.33	0.0082	8.33
750	A3	8.13	8.13	8.10	8.11	8.11	8.12	0.0121	8.12
800	A3	8.05	8.03	8.02	8.02	8.00	8.02	0.0163	8.02
850	A3	7.94	7.95	7.95	7.94	7.95	7.96	0.0075	7.95
900	A3	7.90	7.91	7.92	7.90	7.89	7.96	0.0250	7.91
950	A3	7.82	7.80	7.81	7.81	7.80	7.81	0.0084	7.81
1000	A3	7.71	7.71	7.74	7.72	7.71	7.70	0.0130	7.72

Appendix H continued.

Tooth B1, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	B1	6.94	6.96	6.88	6.85	6.91	6.90	0.0398	6.91
50	B1	6.63	6.62	6.58	6.58	6.57	6.57	0.0264	6.59
100	B1	6.46	6.46	6.48	6.47	6.48	6.46	0.0098	6.47
150	B1	6.41	6.40	6.43	6.40	6.38	6.38	0.0190	6.40
200	B1	6.37	6.38	6.37	6.36	6.37	6.37	0.0063	6.37
250	B1	6.31	6.30	6.31	6.27	6.30	6.29	0.0151	6.30
300	B1	6.28	6.28	6.27	6.26	6.26	6.25	0.0121	6.27
350	B1	6.28	6.28	6.27	6.26	6.26	6.25	0.0121	6.27
400	B1	6.19	6.18	6.17	6.17	6.18	6.19	0.0089	6.18
450	B1	6.15	6.16	6.16	6.15	6.16	6.14	0.0082	6.15
500	B1	6.14	6.15	6.14	6.14	6.14	6.14	0.0041	6.14
550	B1	6.09	6.08	6.08	6.07	6.08	6.09	0.0075	6.08
600	B1	6.00	6.01	5.99	5.98	5.99	5.99	0.0103	5.99
650	B1	5.99	5.99	5.99	5.99	6.00	6.00	0.0052	5.99
700	B1	5.98	5.96	5.98	5.97	5.98	5.95	0.0126	5.97
750	B1	5.95	5.93	5.93	5.92	5.93	5.92	0.0110	5.93
800	B1	5.91	5.90	5.91	5.88	5.89	5.87	0.0163	5.89
850	B1	5.91	5.90	5.91	5.88	5.89	5.87	0.0163	5.89
900	B1	5.91	5.90	5.91	5.88	5.89	5.87	0.0163	5.89
950	B1	5.87	5.86	5.86	5.87	5.86	5.87	0.0055	5.87
1000	B1	5.87	5.86	5.86	5.87	5.86	5.87	0.0055	5.87

Appendix H continued.

Tooth B2, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	B2	12.07	11.98	12.15	12.16	11.95	12.11	0.0879	12.07
50	B2	10.34	10.35	10.35	10.34	10.33	10.31	0.0151	10.34
100	B2	9.89	9.87	9.88	9.86	9.87	9.85	0.0141	9.87
150	B2	9.62	9.62	9.63	9.61	9.63	9.63	0.0082	9.62
200	B2	9.46	9.46	9.47	9.46	9.45	9.46	0.0063	9.46
250	B2	9.37	9.35	9.36	9.37	9.34	9.33	0.0163	9.35
300	B2	9.29	9.29	9.29	9.29	9.29	9.29	0.0000	9.29
350	B2	9.19	9.16	9.16	9.17	9.17	9.18	0.0117	9.17
400	B2	9.14	9.11	9.11	9.12	9.13	9.12	0.0117	9.12
450	B2	9.03	9.05	9.03	9.05	9.04	9.06	0.0121	9.04
500	B2	8.97	9.00	9.01	9.00	8.98	8.99	0.0147	8.99
550	B2	8.91	8.91	8.91	8.90	8.89	8.90	0.0082	8.90
600	B2	8.83	8.84	8.85	8.85	8.84	8.85	0.0082	8.84
650	B2	8.81	8.81	8.80	8.82	8.80	8.83	0.0117	8.81
700	B2	8.77	8.78	8.76	8.75	8.78	8.79	0.0147	8.77
750	B2	8.75	8.73	8.74	8.74	8.73	8.74	0.0075	8.74
800	B2	8.72	8.69	8.69	8.70	8.69	8.71	0.0126	8.70
850	B2	8.72	8.69	8.69	8.70	8.69	8.71	0.0126	8.70
900	B2	8.68	8.68	8.67	8.67	8.69	8.69	0.0089	8.68
950	B2	8.64	8.63	8.65	8.66	8.65	8.65	0.0103	8.65
1000	B2	8.62	8.63	8.64	8.62	8.61	8.62	0.0103	8.62

Appendix H continued.

Tooth B3, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	B3	10.41	10.40	10.08	10.21	10.30	10.20	0.1280	10.27
50	B3	9.02	9.01	8.99	9.00	9.03	9.00	0.0147	9.01
100	B3	8.44	8.42	8.40	8.44	8.39	8.41	0.0207	8.42
150	B3	7.99	8.00	8.04	8.06	7.99	8.01	0.0288	8.02
200	B3	7.90	7.90	7.90	7.90	7.90	7.90	0.0000	7.90
250	B3	7.56	7.60	7.56	7.56	7.55	7.60	0.0223	7.57
300	B3	7.56	7.60	7.56	7.56	7.55	7.60	0.0223	7.57
350	B3	7.56	7.60	7.56	7.56	7.55	7.60	0.0223	7.57
400	B3	7.46	7.47	7.46	7.47	7.45	7.45	0.0089	7.46
450	B3	7.16	7.15	7.19	7.17	7.18	7.18	0.0147	7.17
500	B3	7.00	6.99	7.02	6.95	6.94	6.96	0.0314	6.98
550	B3	6.82	6.81	6.81	6.80	6.81	6.83	0.0103	6.81
600	B3	6.82	6.81	6.81	6.80	6.81	6.83	0.0103	6.81
650	B3	6.65	6.67	6.65	6.66	6.65	6.64	0.0103	6.65
700	B3	6.55	6.56	6.54	6.53	6.56	6.54	0.0121	6.55
750	B3	6.47	6.46	6.45	6.45	6.46	6.44	0.0105	6.46
800	B3	6.04	6.05	6.04	6.02	6.03	6.01	0.0147	6.03
850	B3	5.92	5.92	5.93	5.92	5.91	5.90	0.0103	5.92
900	B3	5.86	5.85	5.84	5.84	5.84	5.84	0.0084	5.85
950	B3	5.66	5.67	5.68	5.67	5.65	5.66	0.0105	5.67
1000	B3	5.65	5.61	5.62	5.63	5.61	5.63	0.0152	5.63

Appendix H continued.

Tooth C1, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	C1	3.85	3.84	3.65	3.64	3.66	3.71	0.0961	3.73
50	C1	3.51	3.52	3.56	3.48	3.51	3.55	0.0293	3.52
100	C1	3.51	3.52	3.56	3.48	3.51	3.55	0.0293	3.52
150	C1	3.45	3.47	3.50	3.50	3.49	3.47	0.0200	3.48
200	C1	3.42	3.40	3.40	3.39	3.41	3.38	0.0141	3.40
250	C1	3.28	3.29	3.29	3.30	3.30	3.27	0.0117	3.29
300	C1	3.24	3.24	3.24	3.24	3.24	3.24	0.0000	3.24
350	C1	3.15	3.17	3.17	3.13	3.14	3.13	0.0183	3.15
400	C1	3.06	3.07	3.06	3.07	3.07	3.06	0.0055	3.07
450	C1	3.06	3.07	3.06	3.07	3.07	3.06	0.0055	3.07
500	C1	2.95	2.98	2.97	2.96	2.98	2.97	0.0117	2.97
550	C1	2.91	2.88	2.90	2.92	2.89	2.90	0.0141	2.90
600	C1	2.86	2.87	2.85	2.85	2.86	2.86	0.0075	2.86
650	C1	2.82	2.83	2.81	2.83	2.81	2.82	0.0089	2.82
700	C1	2.80	2.79	2.78	2.78	2.79	2.79	0.0075	2.79
750	C1	2.78	2.77	2.78	2.78	2.78	2.79	0.0063	2.78
800	C1	2.77	2.75	2.76	2.77	2.75	2.75	0.0098	2.76
850	C1	2.77	2.75	2.76	2.77	2.75	2.75	0.0098	2.76
900	C1	2.72	2.70	2.72	2.70	2.73	2.70	0.0133	2.71
950	C1	2.63	2.59	2.60	2.58	2.59	2.60	0.0172	2.60
1000	C1	2.60	2.60	2.58	2.59	2.60	2.55	0.0197	2.59

Appendix H continued.

Tooth C2, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	C2	11.89	11.85	11.87	11.83	11.80	11.85	0.0313	11.85
50	C2	10.89	10.86	10.88	10.87	10.86	10.87	0.0117	10.87
100	C2	10.50	10.50	10.48	10.47	10.46	10.49	0.0163	10.48
150	C2	10.22	10.20	10.18	10.19	10.20	10.19	0.0137	10.20
200	C2	10.04	10.03	10.02	10.02	10.01	10.02	0.0103	10.02
250	C2	9.90	9.87	9.85	9.86	9.87	9.88	0.0172	9.87
300	C2	9.90	9.87	9.85	9.86	9.87	9.88	0.0172	9.87
350	C2	9.64	9.63	9.63	9.64	9.64	9.63	0.0055	9.64
400	C2	9.48	9.49	9.48	9.47	9.48	9.48	0.0063	9.48
450	C2	9.37	9.38	9.39	9.38	9.37	9.37	0.0082	9.38
500	C2	9.26	9.29	9.29	9.26	9.27	9.28	0.0138	9.28
550	C2	9.17	9.18	9.18	9.17	9.18	9.17	0.0055	9.18
600	C2	9.09	9.09	9.08	9.09	9.10	9.1	0.0075	9.09
650	C2	9.01	9.01	8.99	8.99	9.00	9.00	0.0089	9.00
700	C2	8.90	8.91	8.92	8.91	8.92	8.92	0.0082	8.91
750	C2	8.83	8.84	8.85	8.85	8.85	8.85	0.0084	8.85
800	C2	8.77	8.79	8.78	8.78	8.78	8.79	0.0075	8.78
850	C2	8.66	8.67	8.66	8.68	8.68	8.68	0.0098	8.67
900	C2	8.60	8.62	8.62	8.61	8.59	8.62	0.0126	8.61
950	C2	8.56	8.56	8.54	8.53	8.53	8.54	0.0137	8.54
1000	C2	8.51	8.51	8.52	8.53	8.52	8.53	0.0089	8.52

Appendix H continued.

Tooth C3, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	C3	13.49	13.54	13.52	13.54	13.49	13.52	0.0225	13.52
50	C3	11.04	10.98	10.98	11.00	10.99	10.98	0.0235	11.00
100	C3	10.05	10.03	10.01	10.01	10.05	10.05	0.0197	10.03
150	C3	9.86	9.84	9.86	9.84	9.85	9.84	0.0098	9.85
200	C3	9.76	9.78	9.79	9.77	9.78	9.76	0.0121	9.77
250	C3	9.68	9.66	9.67	9.70	9.65	9.68	0.0175	9.67
300	C3	9.54	9.55	9.54	9.51	9.51	9.51	0.0186	9.53
350	C3	9.54	9.55	9.54	9.51	9.51	9.51	0.0186	9.53
400	C3	9.44	9.45	9.46	9.47	9.48	9.49	0.0187	9.47
450	C3	9.19	9.19	9.20	9.20	9.20	9.18	0.0082	9.19
500	C3	8.83	8.85	8.81	8.80	8.80	8.84	0.0214	8.82
550	C3	7.80	7.79	7.78	7.79	7.77	7.78	0.0105	7.79
600	C3	7.43	7.42	7.41	7.43	7.42	7.42	0.0075	7.42
650	C3	7.25	7.25	7.26	7.23	7.25	7.24	0.0103	7.25
700	C3	7.13	7.12	7.11	7.11	7.10	7.10	0.0117	7.11
750	C3	6.98	6.95	6.95	6.96	6.96	6.95	0.0117	6.96
800	C3	6.84	6.81	6.82	6.82	6.79	6.84	0.0190	6.82
850	C3	6.74	6.75	6.74	6.74	6.73	6.73	0.0075	6.74
900	C3	6.69	6.68	6.67	6.68	6.67	6.68	0.0075	6.68
950	C3	6.65	6.63	6.62	6.63	6.63	6.62	0.0110	6.63
1000	C3	6.65	6.63	6.62	6.63	6.63	6.62	0.0110	6.63

Appendix H continued.

Tooth D1, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	D1	11.47	11.38	11.50	11.51	11.50	11.45	0.0488	11.47
50	D1	9.30	9.23	9.26	9.30	9.24	9.24	0.0313	9.26
100	D1	8.47	8.48	8.48	8.46	8.47	8.47	0.0075	8.47
150	D1	8.04	8.02	8.03	8.03	8.01	8.00	0.0147	8.02
200	D1	7.81	7.81	7.82	7.80	7.79	7.78	0.0147	7.80
250	D1	7.63	7.63	7.63	7.63	7.64	7.67	0.0160	7.64
300	D1	7.57	7.56	7.56	7.55	7.56	7.55	0.0075	7.56
350	D1	7.40	7.41	7.41	7.41	7.41	7.40	0.0052	7.41
400	D1	7.32	7.31	7.32	7.32	7.30	7.31	0.0082	7.31
450	D1	7.12	7.12	7.14	7.14	7.13	7.11	0.0121	7.13
500	D1	7.00	6.99	6.98	6.97	6.98	6.98	0.0103	6.98
550	D1	6.84	6.84	6.82	6.84	6.82	6.83	0.0098	6.83
600	D1	6.75	6.76	6.74	6.74	6.73	6.72	0.0141	6.74
650	D1	6.60	6.59	6.58	6.61	6.60	6.59	0.0105	6.60
700	D1	6.52	6.52	6.49	6.50	6.52	6.51	0.0126	6.51
750	D1	6.41	6.38	6.39	6.37	6.37	6.38	0.0151	6.38
800	D1	6.26	6.26	6.25	6.23	6.23	6.20	0.0232	6.24
850	D1	6.10	6.07	6.09	6.10	6.09	6.09	0.0110	6.09
900	D1	5.95	5.96	5.97	5.95	5.96	5.96	0.0075	5.96
950	D1	5.81	5.79	5.81	5.80	5.82	5.79	0.0121	5.80
1000	D1	5.66	5.67	5.68	5.66	5.67	5.66	0.0082	5.67

Appendix H continued.

Tooth D2, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	D2	11.21	11.11	11.14	11.09	11.02	11.14	0.0631	11.12
50	D2	9.63	9.66	9.68	9.67	9.67	9.65	0.0179	9.66
100	D2	9.27	9.27	9.26	9.28	9.27	9.25	0.0103	9.27
150	D2	9.21	9.22	9.17	9.20	9.21	9.22	0.0187	9.21
200	D2	9.01	9.01	9.02	9.01	9.02	9.00	0.0075	9.01
250	D2	8.94	8.96	8.96	8.98	8.98	8.99	0.0183	8.97
300	D2	8.86	8.86	8.86	8.86	8.86	8.86	0.0000	8.86
350	D2	8.78	8.76	8.77	8.78	8.79	8.78	0.0103	8.78
400	D2	8.70	8.71	8.69	8.70	8.69	8.70	0.0075	8.70
450	D2	8.64	8.66	8.64	8.65	8.65	8.65	0.0075	8.65
500	D2	8.61	8.62	8.62	8.61	8.61	8.61	0.0052	8.61
550	D2	8.54	8.55	8.55	8.55	8.56	8.55	0.0063	8.55
600	D2	8.50	8.48	8.48	8.49	8.49	8.47	0.0105	8.49
650	D2	8.43	8.42	8.41	8.42	8.44	8.42	0.0103	8.42
700	D2	8.32	8.32	8.30	8.33	8.30	8.32	0.0122	8.32
750	D2	8.27	8.28	8.29	8.30	8.32	8.29	0.0172	8.29
800	D2	8.16	8.16	8.14	8.15	8.16	8.16	0.0084	8.16
850	D2	8.10	8.11	8.11	8.10	8.11	8.10	0.0055	8.11
900	D2	7.99	7.98	7.99	7.98	7.98	7.98	0.0052	7.98
950	D2	7.93	7.92	7.92	7.96	7.95	7.94	0.0163	7.94
1000	D2	7.84	7.85	7.84	7.86	7.85	7.86	0.0089	7.85

Appendix H continued.

Tooth D3, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	D3	13.02	12.99	12.89	12.87	13.01	12.99	0.0646	12.96
50	D3	10.82	10.84	10.85	10.86	10.85	10.82	0.0167	10.84
100	D3	10.13	10.16	10.13	10.11	10.14	10.14	0.0164	10.14
150	D3	9.69	9.68	9.65	9.69	9.68	9.66	0.0164	9.68
200	D3	9.41	9.40	9.39	9.40	9.39	9.39	0.0082	9.40
250	D3	9.28	9.29	9.29	9.27	9.26	9.27	0.0121	9.28
300	D3	9.13	9.12	9.11	9.13	9.12	9.11	0.0089	9.12
350	D3	9.03	9.02	9.02	8.99	8.98	9.02	0.0200	9.01
400	D3	8.93	8.90	8.89	8.91	8.89	8.91	0.0152	8.91
450	D3	8.80	8.76	8.77	8.79	8.76	8.77	0.0164	8.78
500	D3	8.77	8.77	8.74	8.75	8.76	8.74	0.0138	8.76
550	D3	8.62	8.61	8.58	8.58	8.58	8.57	0.0200	8.59
600	D3	8.55	8.54	8.54	8.54	8.55	8.52	0.0110	8.54
650	D3	8.52	8.52	8.53	8.52	8.53	8.53	0.0055	8.53
700	D3	8.42	8.43	8.44	8.40	8.40	8.42	0.0160	8.42
750	D3	8.42	8.43	8.44	8.40	8.40	8.42	0.0160	8.42
800	D3	8.37	8.37	8.35	8.37	8.36	8.35	0.0098	8.36
850	D3	8.37	8.37	8.35	8.37	8.36	8.35	0.0098	8.36
900	D3	8.36	8.35	8.35	8.34	8.35	8.37	0.0103	8.35
950	D3	8.34	8.30	8.32	8.33	8.33	8.30	0.0167	8.32
1000	D3	8.31	8.32	8.30	8.31	8.29	8.31	0.0103	8.31

Appendix H continued.

Tooth E1, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	E1	2.90	3.03	2.67	2.81	2.74	2.77	0.1281	2.82
50	E1	2.38	2.41	2.37	2.41	2.41	2.37	0.0204	2.39
100	E1	2.38	2.41	2.37	2.41	2.41	2.37	0.0204	2.39
150	E1	2.22	2.23	2.20	2.20	2.23	2.20	0.0151	2.21
200	E1	2.12	2.13	2.12	2.12	2.12	2.12	0.0041	2.12
250	E1	2.06	2.06	2.07	2.10	2.09	2.08	0.0163	2.08
300	E1	2.06	2.06	2.07	2.10	2.09	2.08	0.0163	2.08
350	E1	2.02	2.02	2.03	2.03	2.03	2.03	0.0052	2.03
400	E1	2.02	2.02	2.03	2.03	2.03	2.03	0.0052	2.03
450	E1	2.02	2.02	2.03	2.03	2.03	2.03	0.0052	2.03
500	E1	1.98	2.00	1.99	1.98	1.98	1.98	0.0084	1.99
550	E1	1.96	1.96	1.96	1.96	1.96	1.95	0.0041	1.96
600	E1	1.94	1.94	1.95	1.96	1.94	1.95	0.0082	1.95
650	E1	1.92	1.92	1.92	1.92	1.92	1.92	0.0000	1.92
700	E1	1.92	1.92	1.92	1.92	1.92	1.92	0.0000	1.92
750	E1	1.91	1.92	1.91	1.91	1.91	1.91	0.0041	1.91
800	E1	1.89	1.89	1.90	1.90	1.90	1.90	0.0052	1.90
850	E1	1.89	1.89	1.90	1.90	1.90	1.90	0.0052	1.90
900	E1	1.88	1.89	1.89	1.89	1.89	1.90	0.0063	1.89
950	E1	1.87	1.87	1.87	1.88	1.88	1.87	0.0052	1.87
1000	E1	1.86	1.86	1.87	1.87	1.88	1.87	0.0075	1.87

Appendix H continued.

Tooth E2, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	E2	7.59	7.83	7.84	7.81	7.82	7.80	0.0950	7.78
50	E2	6.44	6.46	6.51	6.50	6.45	6.49	0.0288	6.48
100	E2	6.30	6.29	6.31	6.28	6.30	6.30	0.0103	6.30
150	E2	5.80	5.81	5.78	5.80	5.81	5.82	0.0137	5.80
200	E2	5.71	5.72	5.73	5.69	5.71	5.73	0.0152	5.72
250	E2	5.30	5.31	5.31	5.31	5.30	5.31	0.0052	5.31
300	E2	5.22	5.23	5.22	5.23	5.22	5.23	0.0055	5.23
350	E2	5.04	5.04	5.04	5.03	5.03	5.03	0.0055	5.04
400	E2	5.04	5.04	5.04	5.03	5.03	5.03	0.0055	5.04
450	E2	4.85	4.81	4.83	4.86	4.86	4.85	0.0197	4.84
500	E2	4.85	4.81	4.83	4.86	4.86	4.85	0.0197	4.84
550	E2	4.71	4.73	4.69	4.69	4.71	4.72	0.0160	4.71
600	E2	4.71	4.73	4.69	4.69	4.71	4.72	0.0160	4.71
650	E2	4.71	4.73	4.69	4.69	4.71	4.72	0.0160	4.71
700	E2	4.71	4.73	4.69	4.69	4.71	4.72	0.0160	4.71
750	E2	4.71	4.73	4.69	4.69	4.71	4.72	0.0160	4.71
800	E2	4.68	4.68	4.65	4.68	4.68	4.67	0.0121	4.67
850	E2	4.62	4.63	4.62	4.63	4.61	4.61	0.0089	4.62
900	E2	4.46	4.46	4.47	4.48	4.51	4.48	0.0186	4.48
950	E2	4.46	4.46	4.47	4.48	4.51	4.48	0.0186	4.48
1000	E2	4.46	4.46	4.47	4.48	4.51	4.48	0.0186	4.48

Appendix H continued.

Tooth E3, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	E3	11.76	11.60	11.58	11.55	11.57	11.55	0.0799	11.60
50	E3	9.54	9.52	9.50	9.50	9.53	9.50	0.0176	9.52
100	E3	8.89	8.86	8.90	8.88	8.91	8.91	0.0194	8.89
150	E3	8.84	8.84	8.81	8.82	8.82	8.81	0.0137	8.82
200	E3	8.72	8.72	8.70	8.71	8.73	8.73	0.0117	8.72
250	E3	8.55	8.54	8.56	8.56	8.57	8.58	0.0141	8.56
300	E3	8.51	8.49	8.50	8.51	8.50	8.51	0.0082	8.50
350	E3	8.51	8.49	8.50	8.51	8.50	8.51	0.0082	8.50
400	E3	8.51	8.49	8.50	8.51	8.50	8.51	0.0082	8.50
450	E3	8.48	8.48	8.47	8.44	8.45	8.45	0.0172	8.46
500	E3	8.42	8.43	8.44	8.41	8.43	8.43	0.0103	8.43
550	E3	8.24	8.24	8.24	8.23	8.22	8.23	0.0082	8.23
600	E3	8.10	8.11	8.10	8.11	8.09	8.10	0.0075	8.10
650	E3	8.03	8.04	8.06	8.05	8.06	8.06	0.0126	8.05
700	E3	7.95	7.96	7.94	7.95	7.97	7.94	0.0117	7.95
750	E3	7.93	7.90	7.93	7.93	7.92	7.94	0.0138	7.93
800	E3	7.91	7.89	7.90	7.90	7.90	7.91	0.0075	7.90
850	E3	7.87	7.89	7.87	7.88	7.87	7.88	0.0082	7.88
900	E3	7.82	7.83	7.83	7.84	7.83	7.84	0.0075	7.83
950	E3	7.83	7.82	7.81	7.82	7.81	7.82	0.0075	7.82
1000	E3	7.83	7.82	7.81	7.82	7.81	7.82	0.0075	7.82

Appendix H continued.

Tooth F1, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	F1	9.22	9.30	9.37	9.38	9.39	9.39	0.0685	9.34
50	F1	8.42	8.47	8.49	8.46	8.43	8.46	0.0259	8.46
100	F1	7.99	8.02	8.03	8.04	8.02	8.02	0.0167	8.02
150	F1	7.85	7.86	7.87	7.87	7.86	7.87	0.0082	7.86
200	F1	7.70	7.72	7.73	7.72	7.72	7.70	0.0122	7.72
250	F1	7.60	7.59	7.59	7.60	7.61	7.63	0.0151	7.60
300	F1	7.53	7.53	7.54	7.52	7.52	7.53	0.0075	7.53
350	F1	7.37	7.38	7.37	7.38	7.38	7.37	0.0055	7.38
400	F1	7.28	7.28	7.28	7.25	7.28	7.27	0.0121	7.27
450	F1	7.16	7.16	7.17	7.17	7.15	7.15	0.0089	7.16
500	F1	7.04	7.07	7.07	7.06	7.07	7.07	0.0121	7.06
550	F1	6.98	6.97	6.98	6.97	6.96	6.97	0.0075	6.97
600	F1	6.90	6.92	6.89	6.89	6.90	6.91	0.0117	6.90
650	F1	6.85	6.85	6.84	6.86	6.85	6.87	0.0103	6.85
700	F1	6.82	6.82	6.82	6.81	6.82	6.80	0.0084	6.82
750	F1	6.77	6.77	6.78	6.78	6.77	6.76	0.0075	6.77
800	F1	6.76	6.74	6.74	6.72	6.76	6.75	0.0152	6.75
850	F1	6.70	6.71	6.70	6.71	6.71	6.70	0.0055	6.71
900	F1	6.70	6.71	6.70	6.69	6.72	6.69	0.0117	6.70
950	F1	6.65	6.66	6.65	6.65	6.64	6.65	0.0063	6.65
1000	F1	6.61	6.60	6.62	6.62	6.62	6.62	0.0084	6.62

Appendix H continued.

Tooth F2, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	F2	12.55	12.52	12.51	12.49	12.55	12.55	0.0256	12.53
50	F2	10.49	10.48	10.47	10.46	10.46	10.45	0.0147	10.47
100	F2	9.86	9.84	9.75	9.76	9.77	9.77	0.0462	9.79
150	F2	9.43	9.45	9.43	9.45	9.44	9.43	0.0098	9.44
200	F2	9.10	9.10	9.09	9.11	9.12	9.10	0.0103	9.10
250	F2	9.00	9.02	9.03	9.00	9.01	9.01	0.0117	9.01
300	F2	8.90	8.88	8.91	8.88	8.91	8.91	0.0147	8.90
350	F2	8.74	8.74	8.73	8.72	8.73	8.72	0.0089	8.73
400	F2	8.53	8.54	8.52	8.52	8.50	8.51	0.0141	8.52
450	F2	8.33	8.36	8.35	8.35	8.35	8.35	0.0098	8.35
500	F2	8.25	8.25	8.27	8.28	8.26	8.27	0.0121	8.26
550	F2	8.15	8.12	8.13	8.14	8.15	8.14	0.0117	8.14
600	F2	8.06	8.05	8.04	8.05	8.03	8.04	0.0105	8.05
650	F2	7.95	7.96	7.96	7.95	7.97	7.96	0.0075	7.96
700	F2	7.92	7.92	7.93	7.92	7.93	7.92	0.0052	7.92
750	F2	7.81	7.82	7.81	7.82	7.82	7.80	0.0082	7.81
800	F2	7.73	7.72	7.71	7.73	7.71	7.73	0.0098	7.72
850	F2	7.64	7.62	7.64	7.62	7.65	7.63	0.0121	7.63
900	F2	7.59	7.59	7.57	7.56	7.57	7.58	0.0121	7.58
950	F2	7.56	7.55	7.52	7.54	7.54	7.54	0.0133	7.54
1000	F2	7.50	7.50	7.49	7.50	7.49	7.48	0.0082	7.49

Appendix H continued.

Tooth F3, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	F3	10.42	10.45	10.42	10.44	10.42	10.42	0.0133	10.43
50	F3	9.47	9.44	9.46	9.45	9.46	9.45	0.0105	9.46
100	F3	9.16	9.16	9.14	9.16	9.16	9.17	0.0098	9.16
150	F3	9.01	8.98	9.03	9.03	9.03	9.03	0.0204	9.02
200	F3	8.92	8.92	8.93	8.93	8.92	8.93	0.0055	8.93
250	F3	8.84	8.85	8.85	8.84	8.85	8.85	0.0052	8.85
300	F3	8.84	8.85	8.85	8.84	8.85	8.85	0.0052	8.85
350	F3	8.82	8.82	8.83	8.82	8.82	8.82	0.0041	8.82
400	F3	8.75	8.74	8.77	8.76	8.76	8.75	0.0105	8.76
450	F3	8.67	8.67	8.67	8.69	8.68	8.68	0.0082	8.68
500	F3	8.67	8.67	8.67	8.69	8.68	8.68	0.0082	8.68
550	F3	8.65	8.65	8.66	8.66	8.66	8.62	0.0155	8.65
600	F3	8.61	8.62	8.61	8.62	8.62	8.62	0.0052	8.62
650	F3	8.61	8.62	8.61	8.59	8.60	8.59	0.0121	8.60
700	F3	8.59	8.58	8.57	8.60	8.57	8.60	0.0138	8.59
750	F3	8.55	8.53	8.54	8.55	8.56	8.54	0.0105	8.55
800	F3	8.52	8.51	8.53	8.54	8.54	8.55	0.0147	8.53
850	F3	8.46	8.48	8.48	8.48	8.47	8.48	0.0084	8.48
900	F3	8.46	8.45	8.43	8.44	8.45	8.44	0.0105	8.45
950	F3	8.44	8.45	8.45	8.43	8.44	8.42	0.0117	8.44
1000	F3	8.43	8.42	8.41	8.41	8.41	8.40	0.0103	8.41

Appendix H continued.

Tooth G1, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	G1	8.66	8.65	8.61	8.61	8.62	8.62	0.0214	8.63
50	G1	7.93	7.95	7.94	7.93	7.95	7.93	0.0098	7.94
100	G1	7.69	7.67	7.67	7.67	7.67	7.68	0.0084	7.68
150	G1	7.57	7.56	7.54	7.56	7.56	7.56	0.0098	7.56
200	G1	7.46	7.44	7.46	7.45	7.45	7.44	0.0089	7.45
250	G1	7.33	7.31	7.30	7.31	7.35	7.35	0.0217	7.33
300	G1	7.27	7.23	7.24	7.25	7.25	7.26	0.0141	7.25
350	G1	7.17	7.16	7.17	7.19	7.18	7.17	0.0103	7.17
400	G1	7.10	7.12	7.10	7.11	7.12	7.11	0.0089	7.11
450	G1	7.02	7.00	7.02	6.98	6.99	6.98	0.0183	7.00
500	G1	6.94	6.94	6.95	6.96	6.92	6.94	0.0133	6.94
550	G1	6.82	6.81	6.82	6.78	6.79	6.80	0.0163	6.80
600	G1	6.70	6.71	6.71	6.72	6.70	6.68	0.0137	6.70
650	G1	6.66	6.68	6.66	6.67	6.67	6.64	0.0137	6.66
700	G1	6.63	6.61	6.61	6.60	6.60	6.61	0.0110	6.61
750	G1	6.57	6.55	6.54	6.54	6.57	6.58	0.0172	6.56
800	G1	6.51	6.53	6.51	6.50	6.51	6.52	0.0103	6.51
850	G1	6.46	6.45	6.47	6.46	6.45	6.47	0.0089	6.46
900	G1	6.44	6.45	6.46	6.45	6.46	6.46	0.0082	6.45
950	G1	6.44	6.45	6.46	6.45	6.46	6.46	0.0082	6.45
1000	G1	6.43	6.43	6.42	6.45	6.39	6.40	0.0219	6.42

Appendix H continued.

Tooth G2, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	G2	10.14	10.15	10.16	10.14	10.16	10.15	0.0089	10.15
50	G2	8.73	8.75	8.73	8.73	8.75	8.73	0.0103	8.74
100	G2	8.34	8.32	8.33	8.36	8.33	8.32	0.0151	8.33
150	G2	7.76	7.74	7.71	7.73	7.75	7.76	0.0194	7.74
200	G2	7.52	7.53	7.51	7.51	7.50	7.51	0.0103	7.51
250	G2	7.24	7.21	7.26	7.28	7.27	7.26	0.0250	7.25
300	G2	7.05	7.06	7.06	7.08	7.07	7.06	0.0103	7.06
350	G2	6.95	6.94	6.93	6.92	6.93	6.93	0.0103	6.93
400	G2	6.70	6.69	6.69	6.68	6.70	6.71	0.0105	6.70
450	G2	6.70	6.69	6.69	6.68	6.70	6.71	0.0105	6.70
500	G2	6.61	6.61	6.61	6.60	6.60	6.60	0.0055	6.61
550	G2	6.38	6.70	6.38	6.38	6.36	6.35	0.1353	6.43
600	G2	6.26	6.25	6.26	6.26	6.27	6.25	0.0075	6.26
650	G2	6.14	6.16	6.15	6.13	6.12	6.13	0.0147	6.14
700	G2	6.07	6.05	6.06	6.07	6.05	6.06	0.0089	6.06
750	G2	5.97	5.98	5.97	5.97	5.98	5.97	0.0052	5.97
800	G2	5.93	5.94	5.92	5.90	5.89	5.90	0.0197	5.91
850	G2	5.85	5.87	5.87	5.87	5.86	5.87	0.0084	5.87
900	G2	5.84	5.84	5.85	5.83	5.85	5.82	0.0117	5.84
950	G2	5.77	5.76	5.76	5.77	5.77	5.75	0.0082	5.76
1000	G2	5.74	5.76	5.73	5.75	5.74	5.75	0.0105	5.75

Appendix H continued.

Tooth G3, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	G3	13.66	13.65	13.64	13.65	13.67	13.65	0.0103	13.65
50	G3	12.28	12.30	12.28	12.27	12.27	12.30	0.0137	12.28
100	G3	11.76	11.74	11.76	11.76	11.79	11.76	0.0160	11.76
150	G3	11.44	11.45	11.45	11.43	11.45	11.44	0.0082	11.44
200	G3	11.16	11.14	11.14	11.17	11.17	11.14	0.0151	11.15
250	G3	10.92	10.93	10.91	10.93	10.93	10.92	0.0082	10.92
300	G3	10.65	10.64	10.62	10.65	10.62	10.65	0.0147	10.64
350	G3	10.52	10.51	10.50	10.51	10.50	10.51	0.0075	10.51
400	G3	10.38	10.36	10.36	10.36	10.37	10.38	0.0098	10.37
450	G3	10.23	10.24	10.23	10.25	10.24	10.24	0.0075	10.24
500	G3	10.06	10.08	10.09	10.10	10.10	10.11	0.0179	10.09
550	G3	9.91	9.92	9.93	9.94	9.94	9.94	0.0126	9.93
600	G3	9.80	9.81	9.80	9.79	9.82	9.80	0.0103	9.80
650	G3	9.75	9.76	9.75	9.76	9.75	9.74	0.0075	9.75
700	G3	9.58	9.58	9.61	9.63	9.61	9.60	0.0194	9.60
750	G3	9.60	9.59	9.57	9.57	9.60	9.57	0.0151	9.58
800	G3	9.48	9.47	9.47	9.48	9.50	9.47	0.0117	9.48
850	G3	9.38	9.40	9.38	9.40	9.41	9.41	0.0137	9.40
900	G3	9.40	9.38	9.39	9.40	9.39	9.40	0.0082	9.39
950	G3	9.36	9.35	9.36	9.38	9.38	9.36	0.0122	9.37
1000	G3	9.25	9.24	9.23	9.26	9.23	9.24	0.0117	9.24

Appendix H continued.

Tooth H1, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	H1	9.55	9.54	9.51	9.48	9.48	9.53	0.0302	9.52
50	H1	7.74	7.74	7.72	7.72	7.73	7.70	0.0152	7.73
100	H1	7.10	7.10	7.13	7.13	7.13	7.12	0.0147	7.12
150	H1	6.80	6.78	6.79	6.78	6.79	6.77	0.0105	6.79
200	H1	6.61	6.62	6.61	6.61	6.62	6.60	0.0075	6.61
250	H1	6.47	6.49	6.49	6.48	6.47	6.48	0.0089	6.48
300	H1	6.39	6.39	6.38	6.38	6.38	6.38	0.0052	6.38
350	H1	6.25	6.23	6.24	6.25	6.25	6.23	0.0098	6.24
400	H1	6.14	6.13	6.12	6.12	6.12	6.12	0.0084	6.13
450	H1	5.97	5.98	6.00	5.98	5.96	5.97	0.0137	5.98
500	H1	5.88	5.90	5.89	5.89	5.87	5.88	0.0105	5.89
550	H1	5.79	5.79	5.77	5.77	5.78	5.78	0.0089	5.78
600	H1	5.69	5.71	5.69	5.70	5.70	5.69	0.0082	5.70
650	H1	5.62	5.61	5.61	5.59	5.59	5.59	0.0133	5.60
700	H1	5.55	5.55	5.55	5.55	5.55	5.55	0.0000	5.55
750	H1	5.49	5.47	5.49	5.48	5.47	5.48	0.0089	5.48
800	H1	5.45	5.44	5.44	5.43	5.43	5.43	0.0082	5.44
850	H1	5.39	5.36	5.37	5.37	5.37	5.37	0.0098	5.37
900	H1	5.31	5.31	5.32	5.33	5.32	5.33	0.0089	5.32
950	H1	5.31	5.29	5.28	5.28	5.30	5.29	0.0117	5.29
1000	H1	5.26	5.26	5.26	5.26	5.26	5.26	0.0000	5.26

Appendix H continued.

Tooth H2, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	H2	11.13	11.12	11.09	11.04	11.00	11.02	0.0543	11.07
50	H2	10.28	10.25	10.25	10.23	10.25	10.25	0.0160	10.25
100	H2	9.84	9.82	9.82	9.81	9.81	9.83	0.0117	9.82
150	H2	9.57	9.59	9.57	9.56	9.57	9.57	0.0098	9.57
200	H2	9.44	9.44	9.43	9.44	9.43	9.44	0.0052	9.44
250	H2	9.26	9.26	9.25	9.24	9.24	9.26	0.0098	9.25
300	H2	9.21	9.19	9.20	9.18	9.16	9.18	0.0175	9.19
350	H2	8.98	8.99	8.98	8.97	8.97	8.97	0.0082	8.98
400	H2	8.86	8.86	8.85	8.86	8.84	8.85	0.0082	8.85
450	H2	8.68	8.69	8.60	8.67	8.64	8.64	0.0333	8.65
500	H2	8.50	8.50	8.49	8.48	8.47	8.47	0.0138	8.49
550	H2	8.34	8.34	8.34	8.34	8.34	8.34	0.0000	8.34
600	H2	8.27	8.27	8.25	8.26	8.26	8.27	0.0082	8.26
650	H2	8.16	8.18	8.15	8.15	8.17	8.15	0.0126	8.16
700	H2	8.14	8.13	8.12	8.13	8.12	8.12	0.0082	8.13
750	H2	8.02	8.02	8.01	8.03	8.00	8.02	0.0103	8.02
800	H2	7.90	7.92	7.92	7.92	7.93	7.91	0.0103	7.92
850	H2	7.83	7.80	7.81	7.80	7.81	7.83	0.0137	7.81
900	H2	7.79	7.78	7.80	7.78	7.79	7.77	0.0105	7.79
950	H2	7.75	7.72	7.73	7.73	7.74	7.73	0.0103	7.73
1000	H2	7.72	7.72	7.73	7.72	7.73	7.71	0.0075	7.72

Appendix H continued.

Tooth H3, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	H3	13.71	13.72	13.68	13.68	13.69	13.65	0.0248	13.69
50	H3	12.02	12.02	12.01	12.03	12.02	12.02	0.0063	12.02
100	H3	11.40	11.38	11.37	11.36	11.37	11.38	0.0137	11.38
150	H3	10.86	10.84	10.86	10.84	10.85	10.84	0.0098	10.85
200	H3	10.59	10.60	10.58	10.59	10.59	10.60	0.0075	10.59
250	H3	10.41	10.38	10.38	10.37	10.35	10.35	0.0225	10.37
300	H3	10.41	10.38	10.38	10.37	10.35	10.35	0.0225	10.37
350	H3	10.00	10.01	10.02	10.03	9.98	9.98	0.0207	10.00
400	H3	9.89	9.89	9.92	9.93	9.92	9.92	0.0172	9.91
450	H3	9.53	9.56	9.54	9.58	9.54	9.54	0.0183	9.55
500	H3	9.36	9.40	9.38	9.37	9.39	9.38	0.0141	9.38
550	H3	9.26	9.26	9.24	9.24	9.27	9.26	0.0122	9.26
600	H3	9.14	9.15	9.14	8.15	9.14	9.15	0.4058	8.98
650	H3	8.92	8.89	8.87	8.88	8.91	8.91	0.0197	8.90
700	H3	8.79	8.79	8.80	8.81	8.80	8.80	0.0075	8.80
750	H3	8.73	8.71	8.69	8.72	8.69	8.68	0.0197	8.70
800	H3	8.59	8.61	8.60	8.61	8.63	8.59	0.0152	8.61
850	H3	8.43	8.42	8.40	8.41	8.40	8.41	0.0117	8.41
900	H3	8.34	8.31	8.35	8.35	8.35	8.34	0.0155	8.34
950	H3	8.33	8.31	8.32	8.33	8.31	8.35	0.0152	8.33
1000	H3	8.34	8.29	8.32	8.33	8.30	8.29	0.0214	8.31

Appendix H continued.

Tooth A4, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	A4	14.86	14.97	14.97	14.97	14.96	14.95	0.0432	14.95
50	A4	14.88	14.92	14.96	14.96	14.91	14.90	0.0325	14.92
100	A4	14.88	14.92	14.96	14.96	14.91	14.90	0.0325	14.92
150	A4	14.88	14.92	14.96	14.96	14.91	14.90	0.0325	14.92
200	A4	14.79	14.80	14.81	14.78	14.79	14.80	0.0105	14.80
250	A4	14.74	14.74	14.75	14.76	14.75	14.75	0.0075	14.75
300	A4	14.82	14.83	14.83	14.81	14.83	14.83	0.0084	14.83
350	A4	14.82	14.83	14.83	14.81	14.83	14.83	0.0084	14.83
400	A4	14.82	14.83	14.83	14.81	14.83	14.83	0.0084	14.83
450	A4	14.80	14.80	14.78	14.80	14.81	14.82	0.0133	14.80
500	A4	14.77	14.77	14.77	14.78	14.78	14.78	0.0055	14.78
550	A4	14.70	14.70	14.70	14.70	14.70	14.69	0.0041	14.70
600	A4	14.70	14.70	14.70	14.70	14.70	14.69	0.0041	14.70
650	A4	14.70	14.70	14.70	14.70	14.70	14.69	0.0041	14.70
700	A4	14.70	14.69	14.69	14.69	14.68	14.67	0.0103	14.69
750	A4	14.70	14.69	14.69	14.69	14.68	14.67	0.0103	14.69
800	A4	14.70	14.69	14.69	14.69	14.68	14.67	0.0103	14.69
850	A4	14.70	14.69	14.69	14.69	14.68	14.67	0.0103	14.69
900	A4	14.70	14.69	14.69	14.69	14.68	14.67	0.0103	14.69
950	A4	14.70	14.69	14.69	14.69	14.68	14.67	0.0103	14.69
1000	A4	14.70	14.69	14.69	14.69	14.68	14.67	0.0103	14.69

Appendix H continued.

Tooth B4, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	B4	11.23	11.16	11.19	11.17	11.22	11.18	0.0279	11.19
50	B4	11.17	11.16	11.14	11.14	11.12	11.15	0.0175	11.15
100	B4	11.17	11.16	11.14	11.14	11.12	11.15	0.0175	11.15
150	B4	11.10	11.09	11.09	11.07	11.08	11.08	0.0105	11.09
200	B4	11.00	11.00	10.98	10.99	11.00	10.98	0.0098	10.99
250	B4	10.95	10.95	10.93	10.94	10.93	10.93	0.0098	10.94
300	B4	10.95	10.95	10.93	10.94	10.93	10.93	0.0098	10.94
350	B4	10.95	10.95	10.93	10.94	10.93	10.93	0.0098	10.94
400	B4	10.95	10.95	10.93	10.94	10.93	10.93	0.0098	10.94
450	B4	10.95	10.95	10.93	10.94	10.93	10.93	0.0098	10.94
500	B4	10.95	10.95	10.93	10.94	10.93	10.93	0.0098	10.94
550	B4	10.85	10.86	10.87	10.84	10.86	10.84	0.0121	10.85
600	B4	10.85	10.86	10.87	10.84	10.86	10.84	0.0121	10.85
650	B4	10.85	10.86	10.87	10.84	10.86	10.84	0.0121	10.85
700	B4	10.82	10.82	10.84	10.82	10.80	10.81	0.0133	10.82
750	B4	10.82	10.82	10.84	10.82	10.80	10.81	0.0133	10.82
800	B4	10.82	10.82	10.84	10.82	10.80	10.81	0.0133	10.82
850	B4	10.82	10.82	10.84	10.82	10.80	10.81	0.0133	10.82
900	B4	10.82	10.82	10.84	10.82	10.80	10.81	0.0133	10.82
950	B4	10.82	10.82	10.84	10.82	10.80	10.81	0.0133	10.82
1000	B4	10.76	10.74	10.75	10.75	10.72	10.74	0.0137	10.74

Appendix H continued.

Tooth C4, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	C4	13.73	13.65	13.72	13.64	13.60	13.61	0.0549	13.66
50	C4	13.66	13.67	13.67	13.67	13.65	13.67	0.0084	13.67
100	C4	13.66	13.67	13.67	13.67	13.65	13.67	0.0084	13.67
150	C4	13.61	13.61	13.62	13.64	13.61	13.60	0.0138	13.62
200	C4	13.53	13.55	13.54	13.56	13.55	13.55	0.0103	13.55
250	C4	13.50	13.51	13.52	13.50	13.51	13.52	0.0089	13.51
300	C4	13.50	13.51	13.52	13.50	13.51	13.52	0.0089	13.51
350	C4	13.50	13.51	13.52	13.50	13.51	13.52	0.0089	13.51
400	C4	13.50	13.51	13.52	13.50	13.51	13.52	0.0089	13.51
450	C4	13.50	13.51	13.52	13.50	13.51	13.52	0.0089	13.51
500	C4	13.50	13.51	13.52	13.50	13.51	13.52	0.0089	13.51
550	C4	13.51	13.50	13.51	13.50	13.51	13.50	0.0055	13.51
600	C4	13.51	13.50	13.51	13.50	13.51	13.50	0.0055	13.51
650	C4	13.51	13.50	13.51	13.50	13.51	13.50	0.0055	13.51
700	C4	13.51	13.50	13.51	13.50	13.51	13.50	0.0055	13.51
750	C4	13.51	13.50	13.51	13.50	13.51	13.50	0.0055	13.51
800	C4	13.51	13.50	13.51	13.50	13.51	13.50	0.0055	13.51
850	C4	13.51	13.50	13.51	13.50	13.51	13.50	0.0055	13.51
900	C4	13.51	13.50	13.51	13.50	13.51	13.50	0.0055	13.51
950	C4	13.51	13.50	13.51	13.50	13.51	13.50	0.0055	13.51
1000	C4	13.51	13.50	13.51	13.50	13.51	13.50	0.0055	13.51

Appendix H continued.

Tooth D4, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	D4	12.41	12.43	12.45	12.46	12.43	12.43	0.0176	12.44
50	D4	12.50	12.50	12.47	12.50	12.49	12.50	0.0121	12.49
100	D4	12.50	12.50	12.47	12.50	12.49	12.50	0.0121	12.49
150	D4	12.45	12.42	12.44	12.42	12.47	12.47	0.0226	12.45
200	D4	12.39	12.39	12.38	12.39	12.39	12.39	0.0041	12.39
250	D4	12.35	12.35	12.35	12.37	12.33	12.35	0.0126	12.35
300	D4	12.35	12.35	12.35	12.37	12.33	12.35	0.0126	12.35
350	D4	12.35	12.35	12.35	12.37	12.33	12.35	0.0126	12.35
400	D4	12.35	12.35	12.35	12.37	12.33	12.35	0.0126	12.35
450	D4	12.35	12.35	12.35	12.37	12.33	12.35	0.0126	12.35
500	D4	12.35	12.35	12.35	12.37	12.33	12.35	0.0126	12.35
550	D4	12.35	12.36	12.35	12.36	12.35	12.35	0.0052	12.35
600	D4	12.35	12.36	12.35	12.36	12.35	12.35	0.0052	12.35
650	D4	12.35	12.36	12.35	12.36	12.35	12.35	0.0052	12.35
700	D4	12.35	12.36	12.35	12.36	12.35	12.35	0.0052	12.35
750	D4	12.35	12.36	12.35	12.36	12.35	12.35	0.0052	12.35
800	D4	12.35	12.36	12.35	12.36	12.35	12.35	0.0052	12.35
850	D4	12.35	12.36	12.35	12.36	12.35	12.35	0.0052	12.35
900	D4	12.35	12.36	12.35	12.36	12.35	12.35	0.0052	12.35
950	D4	12.35	12.36	12.35	12.36	12.35	12.35	0.0052	12.35
1000	D4	12.35	12.36	12.35	12.36	12.35	12.35	0.0052	12.35

Appendix H continued.

Tooth E4, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	E4	12.65	12.59	12.53	12.47	12.39	12.51	0.0909	12.52
50	E4	12.49	12.52	12.50	12.52	12.50	12.52	0.0133	12.51
100	E4	12.49	12.52	12.50	12.52	12.50	12.52	0.0133	12.51
150	E4	12.50	12.49	12.49	12.47	12.51	12.50	0.0137	12.49
200	E4	12.44	12.43	12.44	12.43	12.42	12.41	0.0117	12.43
250	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
300	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
350	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
400	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
450	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
500	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
550	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
600	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
650	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
700	E5	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
750	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
800	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
850	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
900	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
950	E4	12.41	12.40	12.39	12.38	12.38	12.38	0.0126	12.39
1000	E4	12.38	12.37	12.39	12.36	12.39	12.37	0.0121	12.38

Appendix H continued.

Tooth F4, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	F4	10.60	10.60	10.57	10.57	10.62	10.61	0.0207	10.60
50	F4	10.55	10.56	10.57	10.55	10.56	10.57	0.0089	10.56
100	F4	10.55	10.56	10.57	10.55	10.56	10.57	0.0089	10.56
150	F4	10.55	10.56	10.57	10.55	10.56	10.57	0.0089	10.56
200	F4	10.49	10.50	10.50	10.49	10.50	10.49	0.0055	10.50
250	F4	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
300	F4	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
350	F4	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
400	F4	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
450	F4	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
500	F4	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
550	F4	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
600	F4	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
650	F4	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
700	F4	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
750	F5	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
800	F6	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
850	F7	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
900	F8	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
950	F9	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43
1000	F4	10.44	10.43	10.43	10.43	10.42	10.45	0.0103	10.43

Appendix H continued.

Tooth G4, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	G4	11.17	11.20	11.11	11.11	11.05	11.10	0.0535	11.12
50	G4	11.04	11.04	11.03	11.02	11.00	11.00	0.0183	11.02
100	G4	11.04	11.04	11.03	11.02	11.00	11.00	0.0183	11.02
150	G4	10.99	10.98	10.98	10.97	10.97	10.96	0.0105	10.98
200	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
250	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
300	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
350	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
400	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
450	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
500	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
550	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
600	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
650	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
700	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
750	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
800	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
850	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
900	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
950	G4	10.88	10.87	10.88	10.89	10.88	10.91	0.0138	10.89
1000	G4	10.87	10.87	10.87	10.88	10.89	10.87	0.0084	10.88

Appendix H continued.

Tooth H4, Width in mm									
		1	2	3	4	5	6	ST DEV	Average
0	H4	14.25	14.24	14.23	14.20	14.17	14.18	0.0331	14.21
50	H4	14.24	14.24	14.23	14.22	14.24	14.22	0.0098	14.23
100	H4	14.24	14.24	14.23	14.22	14.24	14.22	0.0098	14.23
150	H4	14.24	14.24	14.23	14.22	14.24	14.22	0.0098	14.23
200	H4	14.20	14.22	14.22	14.20	14.22	14.23	0.0122	14.22
250	H4	14.19	14.19	14.19	14.19	14.19	14.20	0.0041	14.19
300	H4	14.19	14.19	14.19	14.19	14.19	14.20	0.0041	14.19
350	H4	14.19	14.19	14.19	14.19	14.19	14.20	0.0041	14.19
400	H4	14.19	14.19	14.19	14.19	14.19	14.20	0.0041	14.19
450	H4	14.19	14.19	14.19	14.19	14.19	14.20	0.0041	14.19
500	H4	14.19	14.19	14.19	14.19	14.19	14.20	0.0041	14.19
550	H4	14.16	14.17	14.16	14.17	14.16	14.17	0.0055	14.17
600	H4	14.16	14.17	14.16	14.17	14.16	14.17	0.0055	14.17
650	H4	14.16	14.17	14.16	14.17	14.16	14.17	0.0055	14.17
700	H4	14.16	14.17	14.16	14.17	14.16	14.17	0.0055	14.17
750	H4	14.16	14.17	14.16	14.17	14.16	14.17	0.0055	14.17
800	H4	14.16	14.17	14.16	14.17	14.16	14.17	0.0055	14.17
850	H4	14.16	14.17	14.16	14.17	14.16	14.17	0.0055	14.17
900	H4	14.16	14.17	14.16	14.17	14.16	14.17	0.0055	14.17
950	H4	14.16	14.17	14.16	14.17	14.16	14.17	0.0055	14.17
1000	H4	14.16	14.17	14.16	14.17	14.16	14.17	0.0055	14.17

Appendix H continued.

Tooth A1, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	A1	0.144	0.140	0.140	0.143	0.141	0.141	0.0016	0.142
50	A1	0.139	0.140	0.139	0.139	0.140	0.140	0.0005	0.140
100	A1	0.139	0.140	0.139	0.139	0.138	0.140	0.0008	0.139
150	A1	0.135	0.137	0.138	0.138	0.137	0.139	0.0014	0.137
200	A1	0.135	0.136	0.136	0.135	0.133	0.135	0.0011	0.135
250	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
300	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
350	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
400	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
450	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
500	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
550	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
600	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
650	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
700	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
750	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
800	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
850	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
900	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
950	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132
1000	A1	0.129	0.132	0.131	0.132	0.135	0.135	0.0023	0.132

Appendix H continued.

Tooth A2, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	A2	0.330	0.329	0.332	0.330	0.330	0.331	0.0010	0.330
50	A2	0.320	0.321	0.321	0.322	0.323	0.320	0.0012	0.321
100	A2	0.316	0.316	0.317	0.315	0.314	0.314	0.0012	0.315
150	A2	0.303	0.302	0.303	0.302	0.302	0.302	0.0005	0.302
200	A2	0.293	0.292	0.292	0.293	0.296	0.296	0.0019	0.294
250	A2	0.287	0.286	0.285	0.288	0.289	0.290	0.0019	0.288
300	A2	0.282	0.282	0.284	0.282	0.283	0.283	0.0008	0.283
350	A2	0.276	0.278	0.279	0.281	0.281	0.278	0.0019	0.279
400	A2	0.269	0.269	0.268	0.269	0.269	0.270	0.0006	0.269
450	A2	0.265	0.267	0.266	0.264	0.263	0.263	0.0016	0.265
500	A2	0.258	0.259	0.256	0.258	0.258	0.256	0.0012	0.258
550	A2	0.254	0.254	0.253	0.252	0.254	0.254	0.0008	0.254
600	A2	0.246	0.247	0.247	0.244	0.245	0.245	0.0012	0.246
650	A2	0.244	0.244	0.244	0.243	0.244	0.243	0.0005	0.244
700	A2	0.238	0.239	0.237	0.236	0.238	0.239	0.0012	0.238
750	A2	0.234	0.240	0.238	0.237	0.237	0.236	0.0020	0.237
800	A2	0.234	0.234	0.234	0.233	0.232	0.231	0.0013	0.233
850	A2	0.230	0.231	0.230	0.230	0.228	0.230	0.0010	0.230
900	A2	0.225	0.224	0.223	0.224	0.225	0.225	0.0008	0.224
950	A2	0.225	0.224	0.223	0.224	0.225	0.225	0.0008	0.224
1000	A2	0.221	0.222	0.222	0.223	0.222	0.223	0.0008	0.222

Appendix H continued.

Tooth A3, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	A3	0.134	0.132	0.128	0.134	0.134	0.129	0.0027	0.132
50	A3	0.121	0.121	0.123	0.123	0.124	0.122	0.0012	0.122
100	A3	0.119	0.119	0.118	0.120	0.118	0.122	0.0015	0.119
150	A3	0.113	0.114	0.113	0.111	0.111	0.113	0.0012	0.113
200	A3	0.113	0.110	0.109	0.109	0.111	0.109	0.0016	0.110
250	A3	0.108	0.107	0.108	0.107	0.107	0.110	0.0012	0.108
300	A3	0.106	0.104	0.105	0.104	0.105	0.107	0.0012	0.105
350	A3	0.104	0.103	0.103	0.102	0.102	0.103	0.0008	0.103
400	A3	0.103	0.101	0.100	0.101	0.100	0.100	0.0012	0.101
450	A3	0.103	0.101	0.100	0.101	0.100	0.100	0.0012	0.101
500	A3	0.098	0.095	0.096	0.099	0.097	0.097	0.0014	0.097
550	A3	0.095	0.094	0.096	0.094	0.094	0.096	0.0010	0.095
600	A3	0.093	0.092	0.090	0.091	0.093	0.094	0.0015	0.092
650	A3	0.093	0.092	0.090	0.091	0.093	0.094	0.0015	0.092
700	A3	0.090	0.088	0.091	0.090	0.091	0.091	0.0012	0.090
750	A3	0.090	0.088	0.091	0.090	0.091	0.091	0.0012	0.090
800	A3	0.092	0.088	0.087	0.088	0.087	0.088	0.0019	0.088
850	A3	0.087	0.087	0.088	0.091	0.087	0.088	0.0015	0.088
900	A3	0.086	0.085	0.086	0.086	0.085	0.087	0.0008	0.086
950	A3	0.086	0.085	0.086	0.086	0.085	0.087	0.0008	0.086
1000	A3	0.084	0.084	0.084	0.083	0.085	0.084	0.0006	0.084

Appendix H continued.

Tooth B1, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	B1	0.045	0.043	0.043	0.043	0.043	0.043	0.0008	0.043
50	B1	0.043	0.042	0.043	0.039	0.042	0.041	0.0015	0.042
100	B1	0.041	0.042	0.042	0.040	0.042	0.041	0.0008	0.041
150	B1	0.040	0.040	0.041	0.039	0.038	0.040	0.0010	0.040
200	B1	0.041	0.040	0.040	0.041	0.040	0.039	0.0008	0.040
250	B1	0.040	0.039	0.039	0.037	0.039	0.039	0.0010	0.039
300	B1	0.040	0.039	0.039	0.037	0.039	0.039	0.0010	0.039
350	B1	0.039	0.038	0.037	0.037	0.036	0.039	0.0012	0.038
400	B1	0.038	0.038	0.038	0.038	0.038	0.038	0.0000	0.038
450	B1	0.034	0.037	0.035	0.034	0.034	0.033	0.0014	0.035
500	B1	0.034	0.037	0.035	0.034	0.034	0.033	0.0014	0.035
550	B1	0.034	0.037	0.035	0.034	0.034	0.033	0.0014	0.035
600	B1	0.034	0.037	0.035	0.034	0.034	0.033	0.0014	0.035
650	B1	0.034	0.037	0.035	0.034	0.034	0.033	0.0014	0.035
700	B1	0.034	0.037	0.035	0.034	0.034	0.033	0.0014	0.035
750	B1	0.034	0.037	0.035	0.034	0.034	0.033	0.0014	0.035
800	B1	0.034	0.037	0.035	0.034	0.034	0.033	0.0014	0.035
850	B1	0.034	0.037	0.035	0.034	0.034	0.033	0.0014	0.035
900	B1	0.034	0.033	0.034	0.035	0.035	0.035	0.0008	0.034
950	B1	0.034	0.033	0.034	0.035	0.035	0.035	0.0008	0.034
1000	B1	0.033	0.034	0.033	0.034	0.033	0.034	0.0005	0.034

Appendix H continued.

Tooth B2, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	B2	0.174	0.176	0.180	0.186	0.178	0.175	0.0044	0.178
50	B2	0.171	0.170	0.172	0.172	0.169	0.169	0.0014	0.171
100	B2	0.166	0.165	0.167	0.164	0.167	0.165	0.0012	0.166
150	B2	0.162	0.160	0.161	0.161	0.163	0.160	0.0012	0.161
200	B2	0.156	0.157	0.157	0.160	0.158	0.157	0.0014	0.158
250	B2	0.154	0.152	0.155	0.154	0.154	0.156	0.0013	0.154
300	B2	0.151	0.152	0.153	0.153	0.154	0.152	0.0010	0.153
350	B2	0.149	0.149	0.149	0.149	0.149	0.149	0.0000	0.149
400	B2	0.147	0.147	0.147	0.149	0.148	0.147	0.0008	0.148
450	B2	0.147	0.147	0.147	0.146	0.147	0.146	0.0005	0.147
500	B2	0.145	0.145	0.144	0.143	0.145	0.143	0.0010	0.144
550	B2	0.143	0.143	0.142	0.141	0.141	0.142	0.0009	0.142
600	B2	0.142	0.142	0.142	0.142	0.142	0.142	0.0000	0.142
650	B2	0.139	0.139	0.140	0.139	0.140	0.139	0.0005	0.139
700	B2	0.136	0.138	0.139	0.137	0.137	0.136	0.0012	0.137
750	B2	0.136	0.138	0.139	0.137	0.137	0.136	0.0012	0.137
800	B2	0.138	0.137	0.135	0.135	0.134	0.135	0.0015	0.136
850	B2	0.138	0.137	0.135	0.135	0.134	0.135	0.0015	0.136
900	B2	0.132	0.133	0.130	0.133	0.132	0.134	0.0014	0.132
950	B2	0.132	0.133	0.130	0.133	0.132	0.134	0.0014	0.132
1000	B2	0.132	0.131	0.131	0.132	0.131	0.131	0.0005	0.131

Appendix H continued.

Tooth B3, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	B3	0.080	0.079	0.085	0.089	0.080	0.083	0.0038	0.083
50	B3	0.075	0.074	0.075	0.075	0.075	0.076	0.0006	0.075
100	B3	0.070	0.071	0.070	0.072	0.072	0.072	0.0010	0.071
150	B3	0.065	0.067	0.064	0.069	0.068	0.067	0.0019	0.067
200	B3	0.066	0.066	0.067	0.065	0.066	0.063	0.0014	0.066
250	B3	0.065	0.064	0.059	0.058	0.066	0.069	0.0042	0.064
300	B3	0.065	0.064	0.059	0.058	0.066	0.069	0.0042	0.064
350	B3	0.059	0.059	0.060	0.059	0.059	0.058	0.0006	0.059
400	B3	0.059	0.057	0.058	0.058	0.056	0.056	0.0012	0.057
450	B3	0.057	0.057	0.057	0.056	0.058	0.056	0.0008	0.057
500	B3	0.056	0.056	0.056	0.056	0.056	0.055	0.0004	0.056
550	B3	0.054	0.055	0.055	0.054	0.053	0.055	0.0008	0.054
600	B3	0.054	0.052	0.050	0.053	0.053	0.052	0.0014	0.052
650	B3	0.054	0.052	0.050	0.053	0.053	0.052	0.0014	0.052
700	B3	0.051	0.050	0.050	0.052	0.053	0.052	0.0012	0.051
750	B3	0.051	0.050	0.050	0.052	0.053	0.052	0.0012	0.051
800	B3	0.048	0.048	0.049	0.046	0.047	0.049	0.0012	0.048
850	B3	0.048	0.048	0.049	0.046	0.047	0.049	0.0012	0.048
900	B3	0.048	0.048	0.049	0.046	0.047	0.049	0.0012	0.048
950	B3	0.048	0.048	0.049	0.046	0.047	0.049	0.0012	0.048
1000	B3	0.047	0.048	0.048	0.047	0.048	0.047	0.0005	0.048

Appendix H continued.

Tooth C1, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	C1	0.080	0.081	0.080	0.081	0.080	0.081	0.0005	0.081
50	C1	0.081	0.079	0.080	0.080	0.079	0.081	0.0009	0.080
100	C1	0.077	0.077	0.078	0.077	0.078	0.077	0.0005	0.077
150	C1	0.076	0.076	0.076	0.076	0.076	0.076	0.0000	0.076
200	C1	0.075	0.073	0.074	0.074	0.075	0.074	0.0008	0.074
250	C1	0.074	0.072	0.069	0.069	0.072	0.074	0.0023	0.072
300	C1	0.074	0.072	0.069	0.069	0.072	0.074	0.0023	0.072
350	C1	0.070	0.071	0.071	0.071	0.071	0.071	0.0004	0.071
400	C1	0.070	0.071	0.070	0.071	0.071	0.070	0.0005	0.071
450	C1	0.068	0.067	0.070	0.068	0.066	0.066	0.0015	0.068
500	C1	0.068	0.067	0.070	0.068	0.066	0.066	0.0015	0.068
550	C1	0.068	0.067	0.070	0.068	0.066	0.066	0.0015	0.068
600	C1	0.066	0.067	0.067	0.066	0.067	0.066	0.0005	0.067
650	C1	0.066	0.067	0.067	0.066	0.067	0.066	0.0005	0.067
700	C1	0.066	0.066	0.064	0.065	0.066	0.064	0.0010	0.065
750	C1	0.066	0.066	0.064	0.065	0.066	0.064	0.0010	0.065
800	C1	0.063	0.064	0.065	0.066	0.065	0.064	0.0010	0.065
850	C1	0.063	0.064	0.065	0.066	0.065	0.064	0.0010	0.065
900	C1	0.063	0.064	0.065	0.066	0.065	0.064	0.0010	0.065
950	C1	0.063	0.064	0.065	0.066	0.065	0.064	0.0010	0.065
1000	C1	0.062	0.061	0.062	0.059	0.062	0.062	0.0012	0.061

Appendix H continued.

Tooth C2, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	C2	0.138	0.139	0.139	0.141	0.140	0.140	0.0010	0.140
50	C2	0.136	0.132	0.133	0.134	0.132	0.133	0.0015	0.133
100	C2	0.130	0.128	0.130	0.130	0.130	0.129	0.0008	0.130
150	C2	0.125	0.126	0.124	0.125	0.127	0.126	0.0010	0.126
200	C2	0.123	0.122	0.124	0.124	0.123	0.124	0.0008	0.123
250	C2	0.116	0.117	0.118	0.119	0.117	0.119	0.0012	0.118
300	C2	0.116	0.117	0.118	0.119	0.117	0.119	0.0012	0.118
350	C2	0.114	0.114	0.117	0.115	0.114	0.115	0.0012	0.115
400	C2	0.114	0.114	0.117	0.115	0.114	0.115	0.0012	0.115
450	C2	0.112	0.112	0.111	0.112	0.112	0.112	0.0004	0.112
500	C2	0.110	0.108	0.110	0.111	0.110	0.111	0.0011	0.110
550	C2	0.107	0.110	0.109	0.107	0.108	0.110	0.0014	0.109
600	C2	0.107	0.107	0.105	0.107	0.106	0.107	0.0008	0.107
650	C2	0.107	0.107	0.105	0.107	0.106	0.107	0.0008	0.107
700	C2	0.104	0.105	0.104	0.107	0.106	0.104	0.0013	0.105
750	C2	0.104	0.105	0.104	0.107	0.106	0.104	0.0013	0.105
800	C2	0.104	0.103	0.104	0.104	0.103	0.105	0.0008	0.104
850	C2	0.102	0.102	0.101	0.101	0.101	0.102	0.0005	0.102
900	C2	0.100	0.101	0.100	0.100	0.100	0.100	0.0004	0.100
950	C2	0.099	0.098	0.096	0.098	0.100	0.101	0.0018	0.099
1000	C2	0.099	0.098	0.096	0.098	0.100	0.101	0.0018	0.099

Appendix H continued.

Tooth C3, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	C3	0.168	0.170	0.169	0.170	0.169	0.170	0.0008	0.169
50	C3	0.156	0.154	0.156	0.155	0.155	0.157	0.0010	0.156
100	C3	0.147	0.146	0.150	0.148	0.150	0.149	0.0016	0.148
150	C3	0.144	0.146	0.145	0.144	0.144	0.145	0.0008	0.145
200	C3	0.141	0.142	0.143	0.143	0.140	0.142	0.0012	0.142
250	C3	0.141	0.137	0.138	0.134	0.135	0.142	0.0032	0.138
300	C3	0.141	0.137	0.138	0.134	0.135	0.142	0.0032	0.138
350	C3	0.133	0.134	0.134	0.132	0.132	0.131	0.0012	0.133
400	C3	0.131	0.131	0.128	0.132	0.131	0.130	0.0014	0.131
450	C3	0.131	0.131	0.128	0.132	0.131	0.130	0.0014	0.131
500	C3	0.127	0.124	0.126	0.126	0.127	0.127	0.0012	0.126
550	C3	0.124	0.123	0.124	0.124	0.125	0.125	0.0008	0.124
600	C3	0.123	0.119	0.121	0.121	0.121	0.122	0.0013	0.121
650	C3	0.123	0.119	0.121	0.121	0.121	0.122	0.0013	0.121
700	C3	0.122	0.120	0.120	0.120	0.121	0.120	0.0008	0.121
750	C3	0.122	0.120	0.120	0.120	0.121	0.120	0.0008	0.121
800	C3	0.120	0.119	0.117	0.118	0.116	0.117	0.0015	0.118
850	C3	0.117	0.118	0.119	0.118	0.119	0.117	0.0009	0.118
900	C3	0.115	0.115	0.114	0.117	0.118	0.115	0.0015	0.116
950	C3	0.115	0.115	0.114	0.117	0.118	0.115	0.0015	0.116
1000	C3	0.114	0.113	0.114	0.113	0.114	0.113	0.0005	0.114

Appendix H continued.

Tooth D1, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	D1	0.106	0.106	0.106	0.107	0.105	0.106	0.0006	0.106
50	D1	0.100	0.099	0.099	0.097	0.098	0.099	0.0010	0.099
100	D1	0.093	0.090	0.092	0.091	0.093	0.092	0.0012	0.092
150	D1	0.089	0.088	0.090	0.088	0.088	0.089	0.0008	0.089
200	D1	0.084	0.083	0.084	0.085	0.084	0.083	0.0008	0.084
250	D1	0.081	0.082	0.083	0.082	0.082	0.084	0.0010	0.082
300	D1	0.081	0.082	0.083	0.082	0.082	0.084	0.0010	0.082
350	D1	0.081	0.079	0.080	0.079	0.080	0.079	0.0008	0.080
400	D1	0.077	0.078	0.077	0.076	0.077	0.077	0.0006	0.077
450	D1	0.077	0.078	0.077	0.076	0.077	0.077	0.0006	0.077
500	D1	0.076	0.075	0.076	0.075	0.074	0.073	0.0012	0.075
550	D1	0.076	0.075	0.076	0.075	0.074	0.073	0.0012	0.075
600	D1	0.072	0.073	0.073	0.072	0.075	0.071	0.0014	0.073
650	D1	0.072	0.073	0.073	0.072	0.075	0.071	0.0014	0.073
700	D1	0.069	0.070	0.071	0.071	0.071	0.071	0.0008	0.071
750	D1	0.069	0.070	0.071	0.071	0.071	0.071	0.0008	0.071
800	D1	0.069	0.068	0.069	0.071	0.071	0.069	0.0012	0.070
850	D1	0.069	0.069	0.067	0.068	0.070	0.069	0.0010	0.069
900	D1	0.066	0.065	0.067	0.065	0.066	0.065	0.0008	0.066
950	D1	0.066	0.065	0.067	0.065	0.066	0.065	0.0008	0.066
1000	D1	0.064	0.065	0.064	0.065	0.064	0.064	0.0005	0.064

Appendix H continued.

Tooth D2, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	D2	0.095	0.093	0.095	0.096	0.095	0.095	0.0010	0.095
50	D2	0.084	0.085	0.085	0.084	0.086	0.085	0.0008	0.085
100	D2	0.079	0.080	0.082	0.081	0.080	0.080	0.0010	0.080
150	D2	0.078	0.073	0.077	0.077	0.079	0.072	0.0028	0.076
200	D2	0.075	0.074	0.073	0.073	0.075	0.073	0.0010	0.074
250	D2	0.071	0.069	0.073	0.076	0.076	0.075	0.0029	0.073
300	D2	0.071	0.069	0.073	0.076	0.076	0.075	0.0029	0.073
350	D2	0.070	0.070	0.070	0.070	0.070	0.070	0.0000	0.070
400	D2	0.070	0.068	0.070	0.069	0.068	0.069	0.0009	0.069
450	D2	0.070	0.068	0.070	0.069	0.068	0.069	0.0009	0.069
500	D2	0.065	0.067	0.066	0.067	0.063	0.064	0.0016	0.065
550	D2	0.065	0.064	0.066	0.065	0.064	0.063	0.0010	0.065
600	D2	0.064	0.064	0.062	0.063	0.065	0.064	0.0010	0.064
650	D2	0.064	0.064	0.062	0.063	0.065	0.064	0.0010	0.064
700	D2	0.061	0.061	0.062	0.061	0.061	0.063	0.0008	0.062
750	D2	0.061	0.061	0.062	0.061	0.061	0.063	0.0008	0.062
800	D2	0.060	0.058	0.059	0.062	0.062	0.061	0.0016	0.060
850	D2	0.060	0.058	0.059	0.062	0.062	0.061	0.0016	0.060
900	D2	0.059	0.058	0.058	0.059	0.060	0.057	0.0010	0.059
950	D2	0.059	0.058	0.058	0.059	0.060	0.057	0.0010	0.059
1000	D2	0.057	0.058	0.058	0.057	0.058	0.057	0.0005	0.058

Appendix H continued.

Tooth D3, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	D3	0.288	0.288	0.293	0.289	0.289	0.288	0.0019	0.289
50	D3	0.269	0.272	0.269	0.270	0.269	0.270	0.0012	0.270
100	D3	0.260	0.259	0.260	0.259	0.258	0.259	0.0008	0.259
150	D3	0.249	0.249	0.248	0.247	0.249	0.250	0.0010	0.249
200	D3	0.242	0.243	0.244	0.243	0.243	0.240	0.0014	0.243
250	D3	0.236	0.237	0.239	0.241	0.241	0.242	0.0024	0.239
300	D3	0.236	0.237	0.239	0.241	0.241	0.242	0.0024	0.239
350	D3	0.230	0.233	0.232	0.232	0.230	0.231	0.0012	0.231
400	D3	0.227	0.226	0.227	0.226	0.227	0.226	0.0005	0.227
450	D3	0.224	0.228	0.226	0.226	0.225	0.226	0.0013	0.226
500	D3	0.221	0.219	0.220	0.222	0.220	0.221	0.0010	0.221
550	D3	0.218	0.216	0.220	0.217	0.216	0.217	0.0015	0.217
600	D3	0.212	0.214	0.215	0.214	0.214	0.215	0.0011	0.214
650	D3	0.212	0.214	0.215	0.214	0.214	0.215	0.0011	0.214
700	D3	0.212	0.212	0.211	0.212	0.211	0.211	0.0005	0.212
750	D3	0.212	0.212	0.211	0.212	0.211	0.211	0.0005	0.212
800	D3	0.211	0.212	0.212	0.209	0.209	0.211	0.0014	0.211
850	D3	0.205	0.206	0.206	0.206	0.207	0.207	0.0008	0.206
900	D3	0.205	0.205	0.204	0.205	0.202	0.203	0.0013	0.204
950	D3	0.205	0.205	0.204	0.205	0.202	0.203	0.0013	0.204
1000	D3	0.200	0.199	0.200	0.200	0.199	0.199	0.0005	0.200

Appendix H continued.

Tooth E1, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	E1	0.080	0.080	0.080	0.080	0.080	0.080	0.0000	0.080
50	E1	0.075	0.076	0.075	0.076	0.076	0.076	0.0005	0.076
100	E1	0.073	0.074	0.073	0.074	0.073	0.073	0.0005	0.073
150	E1	0.071	0.070	0.069	0.071	0.071	0.070	0.0008	0.070
200	E1	0.070	0.069	0.067	0.070	0.070	0.071	0.0014	0.070
250	E1	0.071	0.067	0.063	0.068	0.069	0.068	0.0027	0.068
300	E1	0.071	0.067	0.063	0.068	0.069	0.068	0.0027	0.068
350	E1	0.067	0.068	0.067	0.069	0.065	0.067	0.0013	0.067
400	E1	0.065	0.066	0.065	0.063	0.066	0.062	0.0016	0.065
450	E1	0.065	0.066	0.065	0.063	0.066	0.062	0.0016	0.065
500	E1	0.065	0.066	0.065	0.063	0.066	0.062	0.0016	0.065
550	E1	0.062	0.064	0.063	0.063	0.061	0.063	0.0010	0.063
600	E1	0.062	0.064	0.063	0.063	0.061	0.063	0.0010	0.063
650	E1	0.062	0.064	0.063	0.063	0.061	0.063	0.0010	0.063
700	E1	0.062	0.061	0.062	0.060	0.061	0.062	0.0008	0.061
750	E1	0.062	0.061	0.062	0.060	0.061	0.062	0.0008	0.061
800	E1	0.062	0.061	0.062	0.060	0.061	0.062	0.0008	0.061
850	E1	0.062	0.061	0.062	0.060	0.061	0.062	0.0008	0.061
900	E1	0.059	0.060	0.060	0.060	0.059	0.060	0.0005	0.060
950	E1	0.059	0.060	0.060	0.060	0.059	0.060	0.0005	0.060
1000	E1	0.058	0.059	0.058	0.059	0.060	0.059	0.0008	0.059

Appendix H continued.

Tooth E2, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	E2	0.175	0.173	0.171	0.172	0.171	0.173	0.0015	0.173
50	E2	0.160	0.160	0.160	0.158	0.161	0.160	0.0010	0.160
100	E2	0.155	0.157	0.156	0.154	0.155	0.156	0.0010	0.156
150	E2	0.152	0.152	0.151	0.152	0.151	0.152	0.0005	0.152
200	E2	0.150	0.149	0.150	0.147	0.148	0.149	0.0012	0.149
250	E2	0.144	0.144	0.143	0.143	0.138	0.144	0.0023	0.143
300	E2	0.144	0.144	0.143	0.143	0.138	0.144	0.0023	0.143
350	E2	0.140	0.141	0.140	0.141	0.138	0.140	0.0011	0.140
400	E2	0.135	0.134	0.138	0.138	0.137	0.137	0.0016	0.137
450	E2	0.135	0.134	0.138	0.138	0.137	0.137	0.0016	0.137
500	E2	0.134	0.133	0.135	0.132	0.134	0.133	0.0010	0.134
550	E2	0.130	0.129	0.132	0.131	0.131	0.132	0.0012	0.131
600	E2	0.131	0.128	0.129	0.128	0.128	0.127	0.0014	0.129
650	E2	0.131	0.128	0.129	0.128	0.128	0.127	0.0014	0.129
700	E2	0.127	0.129	0.129	0.125	0.126	0.125	0.0018	0.127
750	E2	0.127	0.129	0.129	0.125	0.126	0.125	0.0018	0.127
800	E2	0.126	0.126	0.126	0.124	0.123	0.124	0.0013	0.125
850	E2	0.126	0.126	0.126	0.124	0.123	0.124	0.0013	0.125
900	E2	0.120	0.119	0.120	0.120	0.119	0.120	0.0005	0.120
950	E2	0.120	0.119	0.120	0.120	0.119	0.120	0.0005	0.120
1000	E2	0.116	0.117	0.121	0.120	0.120	0.121	0.0021	0.119

Appendix H continued.

Tooth E3, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	E3	0.238	0.240	0.242	0.238	0.238	0.239	0.0016	0.239
50	E3	0.222	0.225	0.218	0.223	0.223	0.221	0.0024	0.222
100	E3	0.213	0.213	0.214	0.211	0.212	0.212	0.0010	0.213
150	E3	0.203	0.204	0.207	0.206	0.202	0.204	0.0019	0.204
200	E3	0.200	0.199	0.199	0.200	0.200	0.200	0.0005	0.200
250	E3	0.198	0.197	0.198	0.196	0.194	0.197	0.0015	0.197
300	E3	0.194	0.194	0.193	0.193	0.192	0.193	0.0008	0.193
350	E3	0.189	0.190	0.190	0.190	0.187	0.190	0.0012	0.189
400	E3	0.184	0.185	0.187	0.187	0.187	0.186	0.0013	0.186
450	E3	0.184	0.185	0.187	0.187	0.187	0.186	0.0013	0.186
500	E3	0.182	0.182	0.181	0.182	0.181	0.180	0.0008	0.181
550	E3	0.180	0.178	0.179	0.180	0.180	0.179	0.0008	0.179
600	E3	0.179	0.179	0.178	0.176	0.177	0.177	0.0012	0.178
650	E3	0.175	0.176	0.176	0.175	0.176	0.178	0.0011	0.176
700	E3	0.172	0.173	0.174	0.174	0.175	0.171	0.0015	0.173
750	E3	0.172	0.173	0.174	0.174	0.175	0.171	0.0015	0.173
800	E3	0.171	0.172	0.171	0.168	0.173	0.169	0.0019	0.171
850	E3	0.169	0.170	0.170	0.169	0.169	0.170	0.0005	0.170
900	E3	0.168	0.167	0.170	0.169	0.168	0.169	0.0010	0.169
950	E3	0.168	0.167	0.170	0.169	0.168	0.169	0.0010	0.169
1000	E3	0.165	0.167	0.167	0.168	0.167	0.168	0.0011	0.167

Appendix H continued.

Tooth F1, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	F1	0.071	0.071	0.069	0.073	0.070	0.070	0.0014	0.071
50	F1	0.070	0.070	0.068	0.069	0.068	0.066	0.0015	0.069
100	F1	0.065	0.066	0.068	0.067	0.068	0.068	0.0013	0.067
150	F1	0.065	0.065	0.066	0.066	0.065	0.065	0.0005	0.065
200	F1	0.062	0.062	0.065	0.064	0.063	0.062	0.0013	0.063
250	F1	0.060	0.060	0.062	0.063	0.061	0.063	0.0014	0.062
300	F1	0.060	0.060	0.062	0.063	0.061	0.063	0.0014	0.062
350	F1	0.060	0.060	0.060	0.061	0.059	0.060	0.0006	0.060
400	F1	0.060	0.060	0.060	0.061	0.059	0.060	0.0006	0.060
450	F1	0.058	0.058	0.056	0.057	0.058	0.058	0.0008	0.058
500	F1	0.058	0.058	0.056	0.057	0.058	0.058	0.0008	0.058
550	F1	0.058	0.058	0.056	0.057	0.058	0.058	0.0008	0.058
600	F1	0.058	0.058	0.056	0.057	0.058	0.058	0.0008	0.058
650	F1	0.058	0.058	0.056	0.057	0.058	0.058	0.0008	0.058
700	F1	0.057	0.055	0.059	0.058	0.058	0.059	0.0015	0.058
750	F1	0.056	0.056	0.056	0.056	0.056	0.058	0.0008	0.056
800	F1	0.055	0.057	0.054	0.055	0.055	0.054	0.0011	0.055
850	F1	0.055	0.057	0.054	0.055	0.055	0.054	0.0011	0.055
900	F1	0.055	0.057	0.054	0.055	0.055	0.054	0.0011	0.055
950	F1	0.055	0.057	0.054	0.055	0.055	0.054	0.0011	0.055
1000	F1	0.054	0.054	0.055	0.054	0.053	0.054	0.0006	0.054

Appendix H continued.

Tooth F2, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	F2	0.159	0.160	0.164	0.160	0.161	0.161	0.0017	0.161
50	F2	0.149	0.149	0.148	0.150	0.149	0.150	0.0008	0.149
100	F2	0.145	0.144	0.144	0.143	0.146	0.141	0.0017	0.144
150	F2	0.136	0.139	0.139	0.138	0.140	0.140	0.0015	0.139
200	F2	0.134	0.135	0.134	0.134	0.135	0.133	0.0008	0.134
250	F2	0.131	0.129	0.128	0.131	0.131	0.132	0.0015	0.130
300	F2	0.131	0.129	0.128	0.131	0.131	0.132	0.0015	0.130
350	F2	0.128	0.127	0.126	0.129	0.126	0.127	0.0012	0.127
400	F2	0.125	0.123	0.122	0.127	0.127	0.126	0.0021	0.125
450	F2	0.123	0.123	0.122	0.123	0.122	0.126	0.0015	0.123
500	F2	0.120	0.119	0.120	0.120	0.122	0.121	0.0010	0.120
550	F2	0.119	0.119	0.118	0.119	0.119	0.119	0.0004	0.119
600	F2	0.116	0.118	0.117	0.118	0.119	0.119	0.0012	0.118
650	F2	0.116	0.118	0.117	0.118	0.119	0.119	0.0012	0.118
700	F2	0.116	0.118	0.117	0.118	0.119	0.119	0.0012	0.118
750	F2	0.116	0.118	0.117	0.118	0.119	0.119	0.0012	0.118
800	F2	0.114	0.115	0.115	0.116	0.116	0.115	0.0008	0.115
850	F2	0.114	0.115	0.115	0.116	0.116	0.115	0.0008	0.115
900	F2	0.112	0.111	0.113	0.113	0.114	0.114	0.0012	0.113
950	F2	0.112	0.111	0.113	0.113	0.114	0.114	0.0012	0.113
1000	F2	0.110	0.111	0.109	0.110	0.111	0.110	0.0008	0.110

Appendix H continued.

Tooth F3, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	F3	0.101	0.104	0.106	0.108	0.106	0.105	0.0024	0.105
50	F3	0.101	0.100	0.101	0.102	0.100	0.098	0.0014	0.100
100	F3	0.098	0.098	0.099	0.100	0.099	0.102	0.0015	0.099
150	F3	0.097	0.098	0.098	0.096	0.097	0.098	0.0008	0.097
200	F3	0.096	0.096	0.097	0.096	0.097	0.095	0.0008	0.096
250	F3	0.096	0.095	0.090	0.091	0.095	0.096	0.0026	0.094
300	F3	0.096	0.095	0.090	0.091	0.095	0.096	0.0026	0.094
350	F3	0.096	0.095	0.090	0.091	0.095	0.096	0.0026	0.094
400	F3	0.096	0.095	0.090	0.091	0.095	0.096	0.0026	0.094
450	F3	0.096	0.095	0.090	0.091	0.095	0.096	0.0026	0.094
500	F3	0.096	0.095	0.090	0.091	0.095	0.096	0.0026	0.094
550	F3	0.094	0.094	0.092	0.094	0.092	0.091	0.0013	0.093
600	F3	0.092	0.090	0.089	0.090	0.090	0.090	0.0010	0.090
650	F3	0.092	0.090	0.089	0.090	0.090	0.090	0.0010	0.090
700	F3	0.092	0.090	0.089	0.090	0.090	0.090	0.0010	0.090
750	F3	0.092	0.090	0.089	0.090	0.090	0.090	0.0010	0.090
800	F3	0.092	0.090	0.089	0.090	0.090	0.090	0.0010	0.090
850	F3	0.092	0.090	0.089	0.090	0.090	0.090	0.0010	0.090
900	F3	0.089	0.088	0.088	0.088	0.089	0.090	0.0008	0.089
950	F3	0.089	0.088	0.088	0.088	0.089	0.090	0.0008	0.089
1000	F3	0.089	0.088	0.088	0.088	0.089	0.090	0.0008	0.089

Appendix H continued.

Tooth G1, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	G1	0.076	0.076	0.081	0.075	0.076	0.076	0.0022	0.077
50	G1	0.076	0.075	0.077	0.073	0.076	0.075	0.0014	0.075
100	G1	0.074	0.074	0.074	0.073	0.075	0.074	0.0006	0.074
150	G1	0.072	0.070	0.069	0.072	0.074	0.072	0.0018	0.072
200	G1	0.072	0.072	0.071	0.072	0.072	0.072	0.0004	0.072
250	G1	0.071	0.073	0.073	0.074	0.075	0.075	0.0015	0.074
300	G1	0.070	0.070	0.070	0.069	0.069	0.069	0.0005	0.070
350	G1	0.070	0.070	0.070	0.069	0.069	0.069	0.0005	0.070
400	G1	0.070	0.070	0.070	0.069	0.069	0.069	0.0005	0.070
450	G1	0.066	0.065	0.064	0.065	0.065	0.066	0.0008	0.065
500	G1	0.066	0.065	0.064	0.065	0.065	0.066	0.0008	0.065
550	G1	0.066	0.065	0.064	0.065	0.065	0.066	0.0008	0.065
600	G1	0.066	0.065	0.064	0.065	0.065	0.066	0.0008	0.065
650	G1	0.062	0.064	0.064	0.064	0.065	0.065	0.0011	0.064
700	G1	0.062	0.064	0.064	0.064	0.065	0.065	0.0011	0.064
750	G1	0.062	0.064	0.064	0.064	0.065	0.065	0.0011	0.064
800	G1	0.060	0.064	0.063	0.059	0.058	0.059	0.0024	0.061
850	G1	0.060	0.064	0.063	0.059	0.058	0.059	0.0024	0.061
900	G1	0.060	0.064	0.063	0.059	0.058	0.059	0.0024	0.061
950	G1	0.060	0.064	0.063	0.059	0.058	0.059	0.0024	0.061
1000	G1	0.060	0.064	0.063	0.059	0.058	0.059	0.0024	0.061

Appendix H continued.

Tooth G2, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	G2	0.114	0.117	0.113	0.118	0.108	0.114	0.0035	0.114
50	G2	0.107	0.106	0.107	0.107	0.109	0.107	0.0010	0.107
100	G2	0.103	0.105	0.105	0.104	0.103	0.106	0.0012	0.104
150	G2	0.098	0.097	0.098	0.099	0.101	0.102	0.0019	0.099
200	G2	0.099	0.101	0.097	0.101	0.101	0.100	0.0016	0.100
250	G2	0.093	0.095	0.095	0.096	0.096	0.099	0.0020	0.096
300	G2	0.093	0.095	0.095	0.096	0.096	0.099	0.0020	0.096
350	G2	0.093	0.095	0.095	0.096	0.096	0.099	0.0020	0.096
400	G2	0.090	0.091	0.091	0.089	0.091	0.090	0.0008	0.090
450	G2	0.090	0.091	0.091	0.089	0.091	0.090	0.0008	0.090
500	G2	0.089	0.089	0.088	0.090	0.089	0.088	0.0008	0.089
550	G2	0.089	0.089	0.088	0.090	0.089	0.088	0.0008	0.089
600	G2	0.086	0.088	0.088	0.085	0.087	0.085	0.0014	0.087
650	G2	0.086	0.088	0.088	0.085	0.087	0.085	0.0014	0.087
700	G2	0.080	0.079	0.079	0.081	0.079	0.078	0.0010	0.079
750	G2	0.080	0.079	0.079	0.081	0.079	0.078	0.0010	0.079
800	G2	0.080	0.079	0.079	0.081	0.079	0.078	0.0010	0.079
850	G2	0.080	0.079	0.079	0.081	0.079	0.078	0.0010	0.079
900	G2	0.080	0.079	0.079	0.081	0.079	0.078	0.0010	0.079
950	G2	0.080	0.079	0.079	0.081	0.079	0.078	0.0010	0.079
1000	G2	0.080	0.079	0.079	0.081	0.079	0.078	0.0010	0.079

Appendix H continued.

Tooth G3, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	G3	0.187	0.187	0.188	0.187	0.187	0.187	0.0004	0.187
50	G3	0.184	0.182	0.183	0.183	0.184	0.185	0.0010	0.184
100	G3	0.180	0.179	0.178	0.180	0.181	0.181	0.0012	0.180
150	G3	0.175	0.174	0.176	0.173	0.176	0.176	0.0013	0.175
200	G3	0.172	0.173	0.171	0.172	0.171	0.172	0.0008	0.172
250	G3	0.167	0.166	0.166	0.167	0.168	0.168	0.0009	0.167
300	G3	0.167	0.166	0.166	0.167	0.168	0.168	0.0009	0.167
350	G3	0.163	0.163	0.162	0.163	0.164	0.163	0.0006	0.163
400	G3	0.160	0.161	0.162	0.161	0.162	0.161	0.0008	0.161
450	G3	0.158	0.158	0.157	0.156	0.158	0.159	0.0010	0.158
500	G3	0.154	0.150	0.156	0.155	0.155	0.154	0.0021	0.154
550	G3	0.152	0.151	0.152	0.151	0.152	0.154	0.0011	0.152
600	G3	0.149	0.150	0.149	0.151	0.147	0.146	0.0019	0.149
650	G3	0.149	0.150	0.149	0.151	0.147	0.146	0.0019	0.149
700	G3	0.146	0.145	0.149	0.148	0.148	0.147	0.0015	0.147
750	G3	0.146	0.145	0.149	0.148	0.148	0.147	0.0015	0.147
800	G3	0.143	0.144	0.142	0.144	0.145	0.146	0.0014	0.144
850	G3	0.142	0.141	0.143	0.143	0.144	0.143	0.0010	0.143
900	G3	0.142	0.141	0.143	0.143	0.144	0.143	0.0010	0.143
950	G3	0.140	0.140	0.139	0.140	0.141	0.141	0.0008	0.140
1000	G3	0.140	0.139	0.140	0.140	0.139	0.138	0.0008	0.139

Appendix H continued.

Tooth H1, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	H1	0.077	0.073	0.072	0.071	0.072	0.072	0.0021	0.073
50	H1	0.065	0.065	0.064	0.064	0.066	0.065	0.0008	0.065
100	H1	0.062	0.061	0.062	0.062	0.061	0.063	0.0008	0.062
150	H1	0.059	0.058	0.059	0.059	0.062	0.061	0.0015	0.060
200	H1	0.056	0.057	0.056	0.057	0.054	0.055	0.0012	0.056
250	H1	0.054	0.055	0.055	0.055	0.055	0.055	0.0004	0.055
300	H1	0.054	0.055	0.055	0.055	0.055	0.055	0.0004	0.055
350	H1	0.054	0.055	0.055	0.055	0.055	0.055	0.0004	0.055
400	H1	0.054	0.053	0.053	0.054	0.053	0.054	0.0005	0.054
450	H1	0.054	0.053	0.053	0.054	0.053	0.054	0.0005	0.054
500	H1	0.053	0.053	0.051	0.053	0.051	0.053	0.0010	0.052
550	H1	0.053	0.053	0.051	0.053	0.051	0.053	0.0010	0.052
600	H1	0.051	0.050	0.049	0.050	0.051	0.052	0.0010	0.051
650	H1	0.049	0.050	0.050	0.049	0.050	0.049	0.0005	0.050
700	H1	0.049	0.050	0.050	0.049	0.050	0.049	0.0005	0.050
750	H1	0.049	0.050	0.050	0.049	0.050	0.049	0.0005	0.050
800	H1	0.048	0.047	0.047	0.046	0.048	0.046	0.0009	0.047
850	H1	0.048	0.047	0.047	0.046	0.048	0.046	0.0009	0.047
900	H1	0.048	0.047	0.047	0.046	0.048	0.046	0.0009	0.047
950	H1	0.048	0.047	0.047	0.046	0.048	0.046	0.0009	0.047
1000	H1	0.048	0.047	0.047	0.046	0.048	0.046	0.0009	0.047

Appendix H continued.

Tooth H2, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	H2	0.096	0.092	0.091	0.098	0.097	0.095	0.0028	0.095
50	H2	0.089	0.088	0.088	0.088	0.089	0.089	0.0005	0.089
100	H2	0.086	0.088	0.087	0.085	0.084	0.085	0.0015	0.086
150	H2	0.083	0.084	0.086	0.081	0.083	0.081	0.0019	0.083
200	H2	0.081	0.083	0.080	0.079	0.080	0.079	0.0015	0.080
250	H2	0.077	0.079	0.079	0.076	0.079	0.080	0.0015	0.078
300	H2	0.077	0.079	0.079	0.076	0.079	0.080	0.0015	0.078
350	H2	0.075	0.075	0.074	0.075	0.075	0.076	0.0006	0.075
400	H2	0.073	0.072	0.073	0.073	0.071	0.073	0.0008	0.073
450	H2	0.073	0.072	0.073	0.073	0.071	0.073	0.0008	0.073
500	H2	0.070	0.071	0.070	0.071	0.072	0.071	0.0008	0.071
550	H2	0.068	0.068	0.070	0.068	0.069	0.068	0.0008	0.069
600	H2	0.068	0.068	0.070	0.068	0.069	0.068	0.0008	0.069
650	H2	0.068	0.068	0.070	0.068	0.069	0.068	0.0008	0.069
700	H2	0.067	0.067	0.066	0.066	0.065	0.066	0.0008	0.066
750	H2	0.067	0.067	0.066	0.066	0.065	0.066	0.0008	0.066
800	H2	0.063	0.064	0.063	0.064	0.063	0.063	0.0005	0.063
850	H2	0.063	0.064	0.063	0.064	0.063	0.063	0.0005	0.063
900	H2	0.063	0.064	0.063	0.064	0.063	0.063	0.0005	0.063
950	H2	0.063	0.064	0.063	0.064	0.063	0.063	0.0005	0.063
1000	H2	0.063	0.064	0.063	0.064	0.063	0.063	0.0005	0.063

Appendix H continued.

Tooth H3, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	H3	0.204	0.198	0.208	0.199	0.198	0.200	0.0040	0.201
50	H3	0.192	0.193	0.192	0.193	0.192	0.195	0.0012	0.193
100	H3	0.187	0.187	0.186	0.189	0.187	0.190	0.0015	0.188
150	H3	0.179	0.181	0.182	0.181	0.179	0.181	0.0012	0.181
200	H3	0.176	0.177	0.176	0.180	0.174	0.175	0.0021	0.176
250	H3	0.175	0.174	0.173	0.174	0.174	0.175	0.0008	0.174
300	H3	0.170	0.169	0.169	0.168	0.170	0.170	0.0008	0.169
350	H3	0.165	0.166	0.166	0.165	0.163	0.165	0.0011	0.165
400	H3	0.161	0.158	0.160	0.162	0.160	0.160	0.0013	0.160
450	H3	0.158	0.155	0.156	0.157	0.156	0.157	0.0010	0.157
500	H3	0.153	0.151	0.154	0.154	0.152	0.152	0.0012	0.153
550	H3	0.149	0.150	0.151	0.149	0.151	0.149	0.0010	0.150
600	H3	0.148	0.148	0.149	0.149	0.147	0.147	0.0009	0.148
650	H3	0.148	0.148	0.149	0.149	0.147	0.147	0.0009	0.148
700	H3	0.143	0.143	0.144	0.144	0.144	0.143	0.0005	0.144
750	H3	0.143	0.143	0.144	0.144	0.144	0.143	0.0005	0.144
800	H3	0.140	0.139	0.138	0.139	0.138	0.142	0.0015	0.139
850	H3	0.140	0.139	0.138	0.139	0.138	0.142	0.0015	0.139
900	H3	0.140	0.139	0.138	0.139	0.138	0.142	0.0015	0.139
950	H3	0.136	0.135	0.137	0.137	0.136	0.133	0.0015	0.136
1000	H3	0.135	0.136	0.135	0.136	0.134	0.136	0.0008	0.135

Appendix H continued.

Tooth A4, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	A4	0.175	0.175	0.172	0.172	0.173	0.172	0.0015	0.173
50	A4	0.177	0.176	0.176	0.177	0.176	0.176	0.0005	0.176
100	A4	0.177	0.176	0.176	0.177	0.176	0.176	0.0005	0.176
150	A4	0.176	0.177	0.175	0.177	0.176	0.175	0.0009	0.176
200	A4	0.176	0.173	0.175	0.175	0.175	0.175	0.0010	0.175
250	A4	0.172	0.173	0.172	0.173	0.174	0.174	0.0009	0.173
300	A4	0.172	0.173	0.172	0.173	0.174	0.174	0.0009	0.173
350	A4	0.172	0.173	0.172	0.173	0.174	0.174	0.0009	0.173
400	A4	0.172	0.173	0.172	0.173	0.174	0.174	0.0009	0.173
450	A4	0.172	0.173	0.172	0.173	0.174	0.174	0.0009	0.173
500	A4	0.172	0.173	0.172	0.173	0.174	0.174	0.0009	0.173
550	A4	0.172	0.173	0.172	0.173	0.174	0.174	0.0009	0.173
600	A4	0.170	0.171	0.169	0.169	0.171	0.170	0.0009	0.170
650	A4	0.170	0.171	0.169	0.169	0.171	0.170	0.0009	0.170
700	A4	0.169	0.169	0.169	0.169	0.169	0.170	0.0004	0.169
750	A4	0.169	0.169	0.169	0.169	0.169	0.170	0.0004	0.169
800	A4	0.169	0.169	0.169	0.169	0.169	0.170	0.0004	0.169
850	A4	0.169	0.169	0.169	0.169	0.169	0.170	0.0004	0.169
900	A4	0.169	0.169	0.169	0.169	0.169	0.170	0.0004	0.169
950	A4	0.169	0.169	0.169	0.169	0.169	0.170	0.0004	0.169
1000	A4	0.166	0.166	0.165	0.168	0.167	0.166	0.0010	0.166

Appendix H continued.

Tooth B4, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	B4	0.096	0.096	0.096	0.096	0.096	0.096	0.0000	0.096
50	B4	0.096	0.096	0.095	0.096	0.095	0.095	0.0005	0.096
100	B4	0.093	0.095	0.095	0.096	0.097	0.095	0.0013	0.095
150	B4	0.095	0.095	0.093	0.094	0.094	0.094	0.0008	0.094
200	B4	0.094	0.093	0.094	0.095	0.094	0.094	0.0006	0.094
250	B4	0.093	0.092	0.091	0.092	0.091	0.090	0.0010	0.092
300	B4	0.093	0.092	0.091	0.092	0.091	0.090	0.0010	0.092
350	B4	0.093	0.092	0.091	0.092	0.091	0.090	0.0010	0.092
400	B4	0.091	0.091	0.092	0.090	0.090	0.090	0.0008	0.091
450	B4	0.091	0.091	0.092	0.090	0.090	0.090	0.0008	0.091
500	B4	0.091	0.091	0.092	0.090	0.090	0.090	0.0008	0.091
550	B4	0.091	0.091	0.092	0.090	0.090	0.090	0.0008	0.091
600	B4	0.091	0.091	0.092	0.090	0.090	0.090	0.0008	0.091
650	B4	0.089	0.089	0.085	0.090	0.089	0.088	0.0018	0.088
700	B4	0.089	0.089	0.085	0.090	0.089	0.088	0.0018	0.088
750	B4	0.089	0.089	0.085	0.090	0.089	0.088	0.0018	0.088
800	B4	0.087	0.087	0.088	0.085	0.088	0.087	0.0011	0.087
850	B4	0.087	0.087	0.088	0.085	0.088	0.087	0.0011	0.087
900	B4	0.087	0.087	0.088	0.085	0.088	0.087	0.0011	0.087
950	B4	0.087	0.087	0.088	0.085	0.088	0.087	0.0011	0.087
1000	B4	0.086	0.087	0.086	0.085	0.086	0.087	0.0008	0.086

Appendix H continued.

Tooth C4, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	C4	0.156	0.156	0.156	0.160	0.157	0.156	0.0016	0.157
50	C4	0.160	0.160	0.161	0.162	0.161	0.161	0.0008	0.161
100	C4	0.160	0.160	0.161	0.162	0.161	0.161	0.0008	0.161
150	C4	0.158	0.159	0.159	0.158	0.160	0.160	0.0009	0.159
200	C4	0.157	0.158	0.157	0.158	0.158	0.157	0.0005	0.158
250	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
300	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
350	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
400	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
450	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
500	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
550	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
600	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
650	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
700	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
750	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
800	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
850	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
900	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
950	C4	0.153	0.156	0.153	0.154	0.154	0.157	0.0016	0.155
1000	C4	0.149	0.153	0.152	0.150	0.150	0.151	0.0015	0.151

Appendix H continued.

Tooth D4, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	D4	0.120	0.122	0.120	0.120	0.122	0.122	0.0011	0.121
50	D4	0.121	0.122	0.119	0.121	0.123	0.120	0.0014	0.121
100	D4	0.121	0.122	0.119	0.121	0.123	0.120	0.0014	0.121
150	D4	0.118	0.118	0.118	0.116	0.117	0.118	0.0008	0.118
200	D4	0.117	0.118	0.118	0.118	0.116	0.116	0.0010	0.117
250	D4	0.114	0.116	0.113	0.112	0.113	0.113	0.0014	0.114
300	D4	0.114	0.116	0.113	0.112	0.113	0.113	0.0014	0.114
350	D4	0.114	0.116	0.113	0.112	0.113	0.113	0.0014	0.114
400	D4	0.114	0.116	0.113	0.112	0.113	0.113	0.0014	0.114
450	D4	0.114	0.116	0.113	0.112	0.113	0.113	0.0014	0.114
500	D4	0.114	0.116	0.113	0.112	0.113	0.113	0.0014	0.114
550	D4	0.114	0.116	0.113	0.112	0.113	0.113	0.0014	0.114
600	D4	0.114	0.116	0.113	0.112	0.113	0.113	0.0014	0.114
650	D4	0.114	0.116	0.113	0.112	0.113	0.113	0.0014	0.114
700	D4	0.112	0.112	0.114	0.112	0.112	0.111	0.0010	0.112
750	D4	0.112	0.112	0.114	0.112	0.112	0.111	0.0010	0.112
800	D4	0.112	0.112	0.114	0.112	0.112	0.111	0.0010	0.112
850	D4	0.112	0.112	0.114	0.112	0.112	0.111	0.0010	0.112
900	D4	0.110	0.111	0.110	0.110	0.109	0.110	0.0006	0.110
950	D4	0.110	0.111	0.110	0.110	0.109	0.110	0.0006	0.110
1000	D4	0.109	0.109	0.109	0.109	0.109	0.109	0.0000	0.109

Appendix H continued.

Tooth E4, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	E4	0.114	0.117	0.117	0.117	0.117	0.117	0.0012	0.117
50	E4	0.121	0.119	0.120	0.118	0.119	0.118	0.0012	0.119
100	E4	0.121	0.119	0.120	0.118	0.119	0.118	0.0012	0.119
150	E4	0.117	0.117	0.117	0.117	0.117	0.116	0.0004	0.117
200	E4	0.116	0.116	0.117	0.116	0.116	0.116	0.0004	0.116
250	E4	0.116	0.115	0.114	0.116	0.116	0.117	0.0010	0.116
300	E4	0.116	0.115	0.114	0.116	0.116	0.117	0.0010	0.116
350	E4	0.116	0.115	0.114	0.116	0.116	0.117	0.0010	0.116
400	E4	0.112	0.111	0.113	0.113	0.114	0.114	0.0012	0.113
450	E4	0.112	0.111	0.113	0.113	0.114	0.114	0.0012	0.113
500	E4	0.112	0.111	0.113	0.113	0.114	0.114	0.0012	0.113
550	E4	0.112	0.111	0.113	0.113	0.114	0.114	0.0012	0.113
600	E4	0.112	0.111	0.113	0.113	0.114	0.114	0.0012	0.113
650	E4	0.112	0.111	0.113	0.113	0.114	0.114	0.0012	0.113
700	E4	0.111	0.111	0.112	0.113	0.112	0.112	0.0008	0.112
750	E4	0.111	0.111	0.112	0.113	0.112	0.112	0.0008	0.112
800	E4	0.111	0.111	0.112	0.113	0.112	0.112	0.0008	0.112
850	E4	0.111	0.111	0.112	0.113	0.112	0.112	0.0008	0.112
900	E4	0.110	0.110	0.110	0.110	0.110	0.111	0.0004	0.110
950	E4	0.110	0.110	0.110	0.110	0.110	0.111	0.0004	0.110
1000	E4	0.109	0.109	0.109	0.109	0.109	0.109	0.0000	0.109

Appendix H continued.

Tooth F4, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	F4	0.086	0.088	0.085	0.085	0.086	0.086	0.0011	0.086
50	F4	0.084	0.088	0.085	0.086	0.086	0.086	0.0013	0.086
100	F4	0.084	0.088	0.085	0.086	0.086	0.086	0.0013	0.086
150	F4	0.086	0.085	0.085	0.085	0.084	0.086	0.0008	0.085
200	F4	0.084	0.083	0.083	0.083	0.082	0.084	0.0008	0.083
250	F4	0.087	0.084	0.087	0.083	0.083	0.083	0.0020	0.085
300	F4	0.087	0.084	0.087	0.083	0.083	0.083	0.0020	0.085
350	F4	0.087	0.084	0.087	0.083	0.083	0.083	0.0020	0.085
400	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082
450	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082
500	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082
550	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082
600	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082
650	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082
700	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082
750	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082
800	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082
850	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082
900	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082
950	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082
1000	F4	0.080	0.081	0.083	0.083	0.082	0.083	0.0013	0.082

Appendix H continued.

Tooth G4, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	G4	0.041	0.041	0.041	0.041	0.041	0.041	0.0000	0.041
50	G4	0.040	0.041	0.040	0.041	0.041	0.041	0.0005	0.041
100	G4	0.040	0.041	0.040	0.041	0.041	0.041	0.0005	0.041
150	G4	0.039	0.039	0.040	0.041	0.040	0.040	0.0008	0.040
200	G4	0.039	0.039	0.040	0.040	0.040	0.039	0.0005	0.040
250	G4	0.033	0.039	0.040	0.041	0.041	0.041	0.0031	0.039
300	G4	0.033	0.039	0.040	0.041	0.041	0.041	0.0031	0.039
350	G4	0.033	0.039	0.040	0.041	0.041	0.041	0.0031	0.039
400	G4	0.040	0.040	0.040	0.040	0.040	0.040	0.0000	0.040
450	G4	0.040	0.040	0.040	0.040	0.040	0.040	0.0000	0.040
500	G4	0.040	0.040	0.040	0.040	0.040	0.040	0.0000	0.040
550	G4	0.040	0.040	0.040	0.040	0.040	0.040	0.0000	0.040
600	G4	0.040	0.040	0.040	0.040	0.040	0.040	0.0000	0.040
650	G4	0.040	0.040	0.040	0.040	0.040	0.040	0.0000	0.040
700	G4	0.040	0.040	0.040	0.040	0.040	0.040	0.0000	0.040
750	G4	0.040	0.040	0.040	0.040	0.040	0.040	0.0000	0.040
800	G4	0.040	0.040	0.040	0.040	0.040	0.040	0.0000	0.040
850	G4	0.040	0.040	0.040	0.040	0.040	0.040	0.0000	0.040
900	G4	0.040	0.040	0.040	0.040	0.040	0.040	0.0000	0.040
950	G4	0.039	0.039	0.039	0.040	0.039	0.040	0.0005	0.039
1000	G4	0.039	0.039	0.039	0.040	0.039	0.040	0.0005	0.039

Appendix H continued.

Tooth H4, Mass in g									
		1	2	3	4	5	6	ST DEV	Average
0	H4	0.143	0.143	0.144	0.143	0.143	0.143	0.0004	0.143
50	H4	0.144	0.144	0.144	0.145	0.144	0.144	0.0004	0.144
100	H4	0.144	0.144	0.144	0.145	0.144	0.144	0.0004	0.144
150	H4	0.145	0.141	0.142	0.142	0.143	0.143	0.0014	0.143
200	H4	0.141	0.140	0.143	0.142	0.142	0.141	0.0010	0.142
250	H4	0.137	0.137	0.138	0.137	0.140	0.142	0.0021	0.139
300	H4	0.137	0.137	0.138	0.137	0.140	0.142	0.0021	0.139
350	H4	0.137	0.137	0.138	0.137	0.140	0.142	0.0021	0.139
400	H4	0.137	0.137	0.138	0.137	0.140	0.142	0.0021	0.139
450	H4	0.137	0.137	0.138	0.137	0.140	0.142	0.0021	0.139
500	H4	0.137	0.137	0.138	0.137	0.140	0.142	0.0021	0.139
550	H4	0.137	0.136	0.136	0.137	0.139	0.137	0.0011	0.137
600	H4	0.137	0.136	0.136	0.137	0.139	0.137	0.0011	0.137
650	H4	0.137	0.136	0.136	0.137	0.139	0.137	0.0011	0.137
700	H4	0.137	0.136	0.136	0.137	0.139	0.137	0.0011	0.137
750	H4	0.137	0.136	0.136	0.137	0.139	0.137	0.0011	0.137
800	H4	0.136	0.135	0.136	0.136	0.136	0.136	0.0004	0.136
850	H4	0.136	0.135	0.136	0.136	0.136	0.136	0.0004	0.136
900	H4	0.136	0.135	0.136	0.136	0.136	0.136	0.0004	0.136
950	H4	0.134	0.135	0.135	0.137	0.136	0.135	0.0010	0.135
1000	H4	0.133	0.133	0.134	0.134	0.133	0.134	0.0005	0.134

Appendix H continued.

APPENDIX I

SIGNIFICANCE CORRELATION FOR TAPHONOMY

Linear Regression

	Equation	m	R^2	R	df
A1	y = -0.0023x + 17.068	-0.0023	0.9594	0.97949	23
A2	y = -0.0046x + 18.926	-0.0046	0.8148	0.902663	23
A3	y = -0.0024x + 12.653	-0.0024	0.8273	0.90956	23
B1	y = -0.0014x + 7.9343	-0.0014	0.8975	0.947365	23
B2	y = -0.0026x + 12.559	-0.0026	0.8617	0.928278	23
B3	y = -0.0027x + 9.7489	-0.0027	0.9106	0.954254	23
C1	y = -0.0027x + 14.255	-0.0027	0.8645	0.929785	23
C2	y = -0.0022x + 11.964	-0.0022	0.8375	0.91515	23
C3	y = -0.0002x + 13.473	-0.0002	0.7848	0.885889	23
D1	y = -0.0025x + 12.013	-0.0025	0.8241	0.9078	23
D2	y = -0.0022x + 10.051	-0.0022	0.7919	0.889888	23
D3	y = -0.0028x + 16.689	-0.0028	0.5772	0.759737	23
E1	y = -0.0021x + 13.757	-0.0021	0.6659	0.816027	23
E2	y = -0.004x + 16.37	-0.004	0.7754	0.880568	23
E3	y = -0.0031x + 16.29	-0.0031	0.7419	0.861336	23
F1	y = -0.0018x + 10.081	-0.0018	0.8797	0.937923	23
F2	y = -0.0025x + 14.651	-0.0025	0.7417	0.86122	23
F3	y = -0.0051x + 11.451	-0.0015	0.8234	0.907414	23
G1	y = -0.0019x + 12.072	-0.0019	0.8568	0.925635	23
G2	y = -0.0034x + 13.599	-0.0034	0.8527	0.923418	23
G3	y = -0.0029x + 13.67	-0.0029	0.8683	0.931826	23
H1	y = -0.0021x + 10.98	-0.0021	0.779	0.88261	23
H2	y = -0.0022x + 11.074	-0.0022	0.9095	0.953677	23
H3	y = -0.0032x + 13.885	-0.0032	0.8656	0.930376	23
	Average	-0.002471	0.8213	0.905079	

All Significant at 99%

Appendix I: Data for correlation for shark (*Carcharias taurus*) tooth height loss.

Exponential Regression

	Equation	^	R^2	R	df
A1	y = 21.071x^-0.0473	^-0.0473	0.9253	0.961925	23
A2	y = 27.812x^-0.0879	^-0.0879	0.9831	0.991514	23
A3	y = 16.921x^-0.0699	^-0.0699	0.9843	0.992119	23
B1	y = 10.371x^-0.0614	^-0.0614	0.9318	0.965298	23
B2	y = 17.182^-0.072	^-0.072	0.9671	0.983412	23
B3	y = 15.481x^-0.104	^-0.104	0.9559	0.977701	23
C1	y = 19.016x^-0.0662	^-0.0662	0.9662	0.982955	23
C2	y = 15.905x^-0.0653	^-0.0653	0.9816	0.990757	23
C3	y = 16.39x^-0.0468	^-0.0468	0.9669	0.983311	23
D1	y = 16.383x^-0.0716	^-0.0716	0.9809	0.990404	23
D2	y = 13.725x^0.073	^-0.073	0.9757	0.987775	23
D3	y = 20.684x^-0.0528	^-0.0528	0.9665	0.983107	23
E1	y = 16.414x^-0.0447	^-0.0447	0.9649	0.982293	23
E2	y = 23.484x^-0.0886	^-0.0886	0.9832	0.991564	23
E3	y = 21.005x^-0.0612	^-0.0612	0.9644	0.982039	23
F1	y = 13.267x^-0.0627	^-0.0627	0.9701	0.984937	23
F2	y = 18.598x^-0.057	^-0.057	0.9903	0.995138	23
F3	y = 13.88x^-0.0449	^-0.0449	0.968	0.98387	23
G1	y = 15.273x^-0.0545	^-0.0545	0.9599	0.979745	23
G2	y = 20.408x^-0.0925	^-0.0925	0.9794	0.989646	23
G3	y = 19.197x^-0.0768	^-0.0768	0.9814	0.990656	23
H1	y = 14.288x^-0.0624	^-0.0624	0.9746	0.987218	23
H2	y = 15.374x^-0.0736	^-0.00736	0.963	0.981326	23
H3	y = 20.139x^-0.0845	^-0.00845	0.9681	0.983921	23
	Average	#DIV/0!	0.96885833	0.984276	

All Significant at 99%

Appendix I continued: Data for correlation for shark (*Carcharias taurus*) tooth height loss.

Linear Regression

	Equation	m	R^2	R	df
A1	y = -0.001x + 8.3827	-0.001	0.9651	0.982395	23
A2	y = -0.0049x + 11.354	-0.0049	0.8448	0.91913	23
A3	y = -0.0033x + 10.613	-0.0033	0.7771	0.881533	23
B1	y = -0.0008x + 6.5817	-0.0008	0.8881	0.942391	23
B2	y = -0.002x + 10.228	-0.002	0.6189	0.786702	23
B3	y = -0.0036x + 8.937	-0.0036	0.9014	0.949421	23
C1	y = -0.0011x + 3.5791	-0.0011	0.9593	0.979439	23
C2	y = -0.0026x + 10.769	-0.0026	0.8729	0.934291	23
C3	y = -0.0055x + 11.318	-0.0055	0.8708	0.933167	23
D1	y = -0.0038x + 9.1344	-0.0038	0.7876	0.887468	23
D2	y = -0.002x + 9.7294	-0.002	0.7623	0.873098	23
D3	y = -0.0028x + 10.505	-0.0028	0.6236	0.789683	23
E1	y = -0.0006x + 2.3676	-0.0006	0.6836	0.826801	23
E2	y = -0.0023x + 6.3019	-0.0023	0.7106	0.842971	23
E3	y = -0.0021x + 9.5274	-0.0021	0.6008	0.775113	23
F1	y = -0.002x + 8.2983	-0.002	0.8101	0.900056	23
F2	y = -0.0033x + 10.288	-0.0033	0.7454	0.863366	23
F3	y = -0.0012x + 9.3856	-0.0012	0.6326	0.795362	23
G1	y = -0.0018x + 7.9088	-0.0018	0.8766	0.936269	23
G2	y = -0.0033x + 8.498	-0.0033	0.8142	0.90233	23
G3	y = -0.0033x + 12.076	-0.0033	0.8317	0.911976	23
H1	y = -0.0028x + 7.5638	-0.0028	0.7299	0.854342	23
H2	y = -0.0028x + 10.14	-0.0028	0.9066	0.952155	23
H3	y = -0.0042x + 11.833	-0.0042	0.8564	0.925419	23
	Average	-0.002629	0.7946	0.88937	

All significant at 99%

Appendix I continued: Data for correlation for shark (*Carcharias taurus*) tooth width loss.

Exponential Regression

	Equation	^	R^2	R	df
A1	y = 10.178x^-0.0437	^-0.0437	0.844	0.918695	23
A2	y = 24.539x^-0.1742	^-0.1742	0.9647	0.982191	23
A3	y = 17.112x^-0.1119	^-0.1119	0.9746	0.987218	23
B1	y = 7.9361x^-0.0431	^-0.0431	0.9429	0.97103	23
B2	y = 13.056x^-0.0604	^-0.0604	0.9977	0.998849	23
B3	y = 17.717x^-0.1554	^-0.1554	0.884	0.940213	23
C1	y = 6.0813x^-0.1173	^-0.1173	0.8982	0.947734	23
C2	y = 15.683x^-0.086	^-0.086	0.9627	0.981173	23
C3	y = 26.36x^-0.1932	^-0.1932	0.8045	0.896939	23
D1	y = 17.704x^-0.1548	^-0.15.48	0.9359	0.967419	23
D2	y = 12.758x^-0.0659	^-0.0659	0.9266	0.962601	23
D3	y = 15.209x^-0.0982	^-0.0982	0.9929	0.996444	23
E1	y = 3.463x^-0.0898	^-0.0898	0.9703	0.985038	23
E2	y = 11.272x^-0.1344	^-0.1344	0.9732	0.986509	23
E3	y = 12.209x^-0.0638	^-0.0638	0.945	0.972111	23
F1	y = 12.083x^-0.0865	^-0.0865	0.9812	0.990555	23
F2	y = 16.764x^-0.1149	^-0.1149	0.9854	0.992673	23
F3	y = 10.871x^-0.0366	^-0.0366	0.989	0.994485	23
G1	y = 11.149x^-0.0787	^-0.0787	0.9505	0.974936	23
G2	y = 16.582x^-0.1521	^-0.1521	0.9812	0.990555	23
G3	y = 18.828x^-0.1015	^-0.1015	0.9819	0.990909	23
H1	y = 13.233x^-0.132	^-0.132	0.9849	0.992421	23
H2	y = 16.091x^-0.1042	^-0.1042	0.9496	0.974474	23
H3	y = 21.321x^-0.1342	^-0.1342	0.9573	0.978417	23
	Average	#DIV/0!	0.94909167	0.9739	

All significant at 99%

Appendix I continued: Data for correlation for shark (*Carcharias taurus*) tooth width loss.

Linear Regression

	Equation	m	R^2	R	df
A1	y = -0.0001x + 0.3184	-1.00E-04	0.9658	0.982751	23
A2	y = -7E-06x + 0.1372	-7.00E-06	0.5271	0.726017	23
A3	y = -4E-05x + 0.1206	-4.00E-05	0.9191	0.958697	23
B1	y = -9E-06x + 0.0413	-9.00E-06	0.8292	0.910604	23
B2	y = -4E-05x + 0.1677	-4.00E-05	0.9224	0.960417	23
B3	y = -3E-05x + 0.0731	-3.00E-05	0.8955	0.946309	23
C1	y = -2E-05x + 0.0779	-2.00E-05	0.9152	0.956661	23
C2	y = -4E-05x + 0.1311	-4.00E-05	0.929	0.963846	23
C3	y = -4E-05x + 0.153	-4.00E-05	0.8834	0.939894	23
D1	y = -3E-05x + 0.0947	-3.00E-05	0.8848	0.940638	23
D2	y = -3E-05x + 0.0831	-3.00E-05	0.8704	0.932952	23
D3	y = -7E-05x + 0.2636	-7.00E-05	0.8783	0.937177	23
E1	y = -2E-05x + 0.074	-2.00E-05	0.8714	0.933488	23
E2	y = -4E-05x + 0.1589	-4.00E-05	0.9135	0.955772	23
E3	y = -6E-05x + 0.2163	-6.00E-05	0.8602	0.92747	23
F1	y = -1E-05x + 0.0669	-1.00E-05	0.8781	0.93707	23
F2	y = -4E-05x + 0.1454	-4.00E-05	0.8508	0.922388	23
F3	y = -1E-05x + 0.0998	-1.00E-05	0.8449	0.919184	23
G1	y = -2E-05x + 0.0753	-2.00E-05	0.9445	0.971854	23
G2	y = -3E-05x + 0.1065	-3.00E-05	0.9225	0.960469	23
G3	y = -5E-05x + 0.1816	-5.00E-05	0.9576	0.97857	23
H1	y = -2E-05x + 0.0633	-2.00E-05	0.8203	0.905704	23
H2	y = -3E-05x + 0.0874	-3.00E-05	0.9158	0.956974	23
H3	y = -6E-05x + 0.1902	-6.00E-05	0.9417	0.970412	23
Average		-3.53E-05	0.88089583	0.937305	

All Significant at 99%

Appendix I continued: Data for correlation for shark (*Carcharias taurus*) tooth mass loss.

Exponential Regression

	Equation	^	R^2	R	df
A1	y = .1494x^-0.0188	^-0.0	0.7619	0.872869	23
A2	y = .6013x^-0.1394	^-0.1395	0.9271	0.96286	23
A3	y = .2217x^-0.1356	^-0.1356	0.9505	0.974936	23
B1	y = .0605x^-0.0846	^-0.0846	0.8739	0.934826	23
B2	y = .255x^-0.0934	^-0.0934	0.9641	0.981886	23
B3	y = .157x^-0.1705	^-0.1705	0.949	0.974166	23
C1	y = .115x^-0.0855	^-0.0855	0.9576	0.97857	23
C2	y = .2134x^-0.1081	^-0.1081	0.9547	0.977088	23
C3	y = .2502x^-0.1109	^-0.1109	0.9592	0.979388	23
D1	y = .1775x^-0.1406	^-0.1406	0.9638	0.981733	23
D2	y = .1503x^-0.1344	^-0.1344	0.9525	0.975961	23
D3	y = .4163x^-0.1028	^-0.1028	0.971	0.985393	23
E1	y = .1082x^-0.0855	^-0.0855	0.9713	0.985546	23
E2	y = .2547x^-0.1061	^-0.1061	0.9446	0.971905	23
E3	y = .3385x^-0.101	^-0.101	0.988	0.993982	23
F1	y = .0976x^-0.0835	^-0.0835	0.9646	0.982141	23
F2	y = .2298x^-0.103	^-0.103	0.9787	0.989293	23
F3	y = .121x^-0.0441	^-0.0441	0.931	0.964883	23
G1	y = .1105x^-0.0847	^-0.0847	0.8609	0.927847	23
G2	y = .1808x^-0.118	^-0.118	0.8966	0.94689	23
G3	y = .2894x^-0.1025	^-0.1025	0.9384	0.96871	23
H1	y = .1024x^-0.1141	^-0.1141	0.9557	0.977599	23
H2	y = .1569x^-0.1302	^-0.1302	0.9454	0.972317	23
H3	y = .3489x^-0.1336	^-0.1336	0.9429	0.97103	23
Average		#DIV/0!	0.93764167	0.967992	

All Significant at 99%

Appendix I continued: Data for correlation for shark (*Carcharias taurus*) tooth mass loss.

Linear Regression

	Equation	m	R^2	R	df
A4	y = -0.0002x + 3.4001	-0.0002	0.517	0.719027	7
B4	y = -0.0003x + 3.2208	-0.0003	0.5261	0.725328	7
C4	y = -0.0002x + 3.1725	-0.0002	0.5215	0.72215	7
D4	y = -0.0003x + 2.7775	-0.0003	0.8282	0.910055	7
E4	y = -0.0002x + 2.9189	-0.0002	0.7792	0.882723	7
F4	y = -0.0002x + 2.2564	-0.0002	0.663	0.814248	7
G4	y = -1E-04x + 1.6035	-1.00E-04	0.4245	0.651537	7
H4	y = -0.0002x + 3.4021	-0.0002	0.5748	0.758156	7
Average		-0.000213	0.6042875	0.772903	

A4, B4, C4-95%
D4, E4, F4-99%
G4-90%
H4-98%
Average significant at 98%

Appendix I continued: Data for correlation for ray (*Rhinoptera bonasus*) tooth height loss.

Exponential Regression

	Equation	^	R^2	R	df
A4	y = 3.7103x^-0.0192	^-0.0192	0.7086	0.841784	7
B4	y = 3.5915x^-0.027	^-0.027	0.864	0.929516	7
C4	y = 3.4776x^-0.0202	^-0.0202	0.7758	0.880795	7
D4	y = 3.184x^-0.0318	^-0.318	0.9068	0.95226	7
E4	y = 3.2392x^-0.0243	^-0.0243	0.8786	0.937337	7
F4	y = 2.5027x^-0.237	^-0..237	0.9016	0.949526	7
G4	y = 1.7211x^-0.0178	^-0.0178	0.7743	0.879943	7
H4	y = 3.7292x^-0.0211	^-0.0211	0.8831	0.939734	7
	Average	#DIV/0!	0.8366	0.913862	

All significant at 99%

Appendix I continued: Data for correlation for ray (*Rhinoptera bonasus*) tooth height loss.

Linear Regression

	Equation	m	R^2	R	df
A4	y = -0.0003x + 14.908	-0.0003	0.8147	0.902607	7
B4	y = -0.0004x + 11.113	-0.0004	0.8683	0.931826	7
C4	y = -0.0001x + 13.606	-0.0001	0.5442	0.737699	7
D4	y = -0.0001x + 12.428	-0.0001	0.4602	0.67838	7
E4	y = -0.0001x + 12.471	-0.0001	0.5511	0.742361	7
F4	y = -0.0001x + 10.527	-0.0001	0.5403	0.735051	7
G4	y = -0.0001x + 10.984	-0.0001	0.448	0.669328	7
H4	y = -7E-05x + 14.223	-7.00E-05	0.8051	0.897274	7
Average		-0.000159	0.6289875	0.786816	

A4, B4, H4-99%
C4, E4, F4-95%
D4, G4-90%
Average - significant at 98%

Appendix I continued: Data for correlation for ray (*Rhinoptera bonasus*) tooth width loss.

Exponential Regression

	Equation	^	R^2	R	df
A4	y = 15.358x^-0.0066	^-0.0066	0.8233	0.907359	7
B4	y = 11.744x^-0.0122	^-0.0122	0.9298	0.964261	7
C4	y = 13.876x^-0.0042	^-0.0042	0.7699	0.877439	7
D4	y = 12.669x^-0.0039	^-0.0039	0.7205	0.848823	7
E4	y = 12.681x^-0.0036	^-0.0036	0.7526	0.867525	7
F4	y = 10.758x^-0.0047	^-0.0047	0.732	0.85557	7
G4	y = 11.186x^-0.0043	^-0.0043	0.692	0.831865	7
H4	y = 14.36x^-0.002	^-0.002	0.8882	0.942444	7
	Average	#DIV/0!	0.7885375	0.886911	

All significant at 99%

Appendix I continued: Data for correlation for ray (*Rhinoptera bonasus*) tooth width loss.

Linear Regression

	Equation	m	R^2	R	df
A4	y = -7E-06x + 0.176	-7.00E-06	0.7209	0.849058	7
B4	y = -1E-05x + 0.0954	-1.00E-05	0.9492	0.974269	7
C4	y = -6E-06x + 0.1582	-6.00E-06	0.5495	0.741283	7
D4	y = -1E-05x + 0.1192	-1.00E-05	0.8023	0.895712	7
E4	y = -9E-06x + 0.118	-9.00E-06	0.8914	0.94414	7
F4	y = -4E-06x + 0.0853	-4.00E-06	0.7124	0.844038	7
G4	y = -5E-07x + 0.0402	-5.00E-07	0.1039	0.322335	7
H4	y = -9E-06x + 0.143	-9.00E-06	0.8698	0.932631	7
Average		-6.94E-06	7.00E-01	0.812933	

A4, B4, D4, E4, F4, H4-99%
C4-95%
G4 - not at all
Average significant at 99%

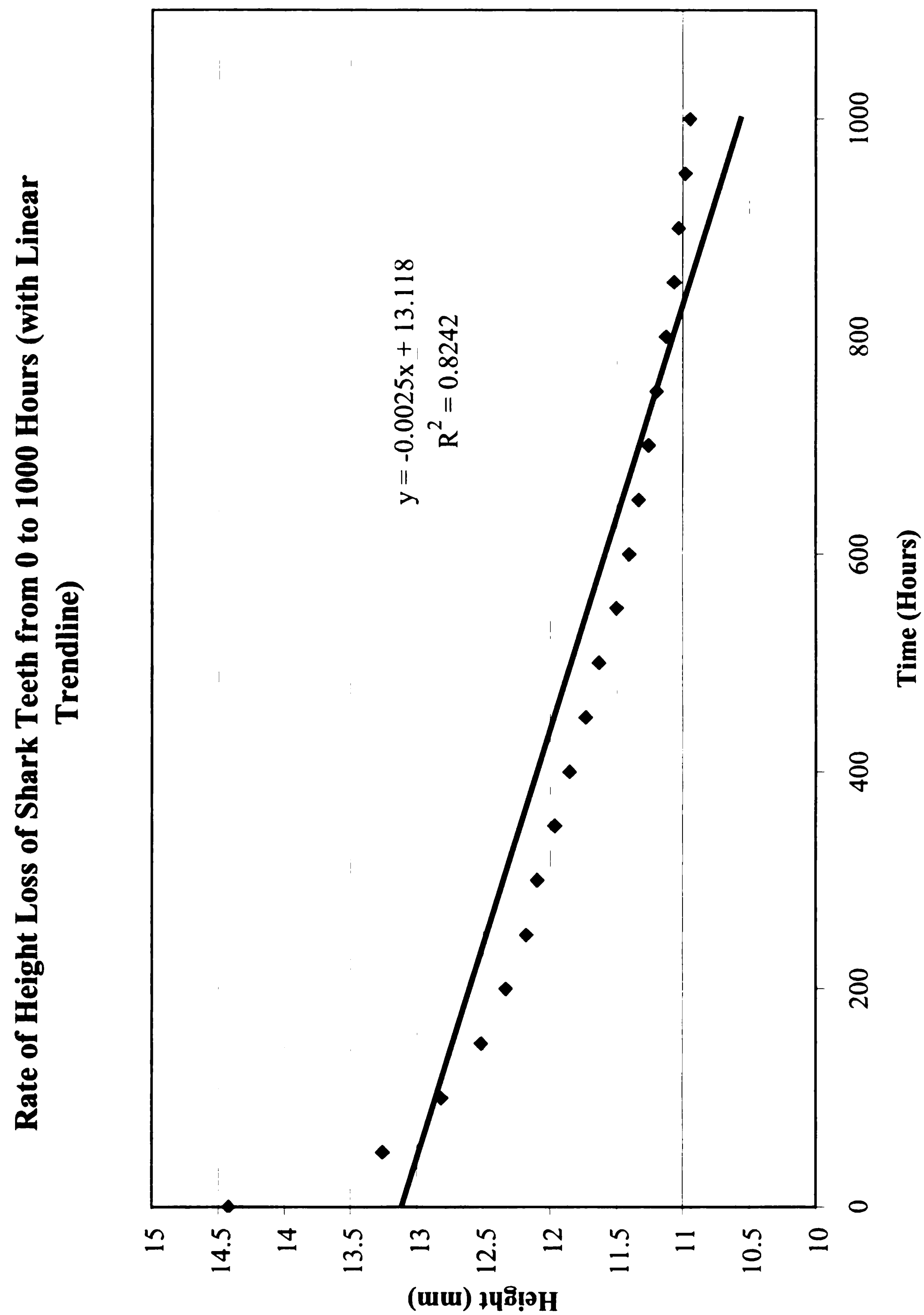
Appendix I continued: Data for correlation for ray (*Rhinoptera bonasus*) tooth mass loss.

Exponential Regression

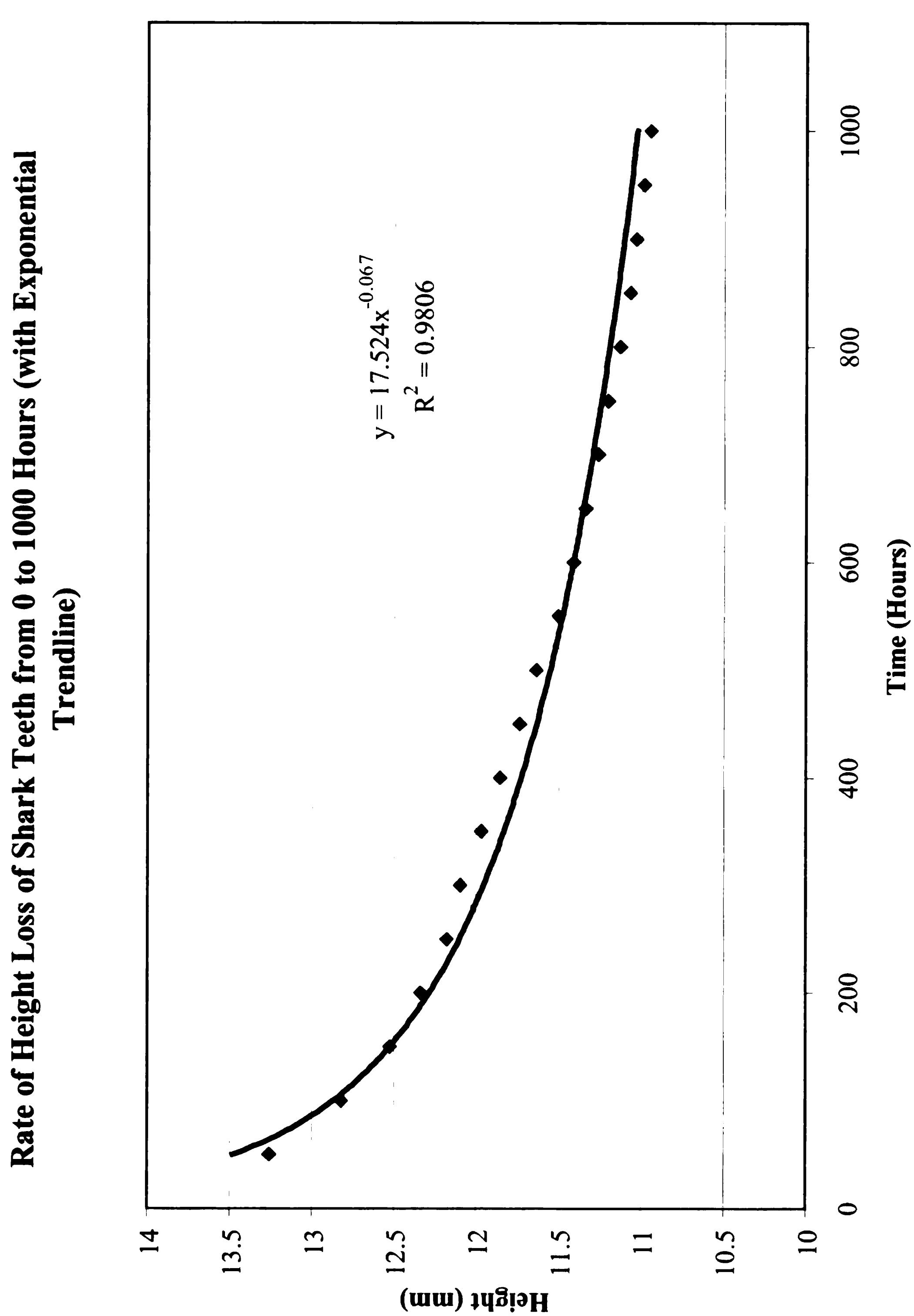
	Equation	^	R^2	R	df
A4	y = .1921x^-0.0186	^-0.0186	0.8199	0.905483	7
B4	y = .1126x^-0.0368	^-0.0368	0.8897	0.943239	7
C4	y = .1715x^-0.0165	^-0.0165	0.7636	0.873842	7
D4	y = .1379x^-0.0319	^-0.0319	0.8823	0.939308	7
E4	y = .01354x^-0.0291	^-0.0291	0.9122	0.955092	7
F4	y = .0931x^-0.0192	^-0.0192	0.7979	0.893252	7
G4	y = .0409x^-0.0042	^-0.0042	0.0963	0.310322	7
H4	y = .16x^-0.0243	^-0.0243	0.9176	0.957914	7
	Average	#DIV/0!	7.60E-01	0.847307	

All significant at 99%
save for G4

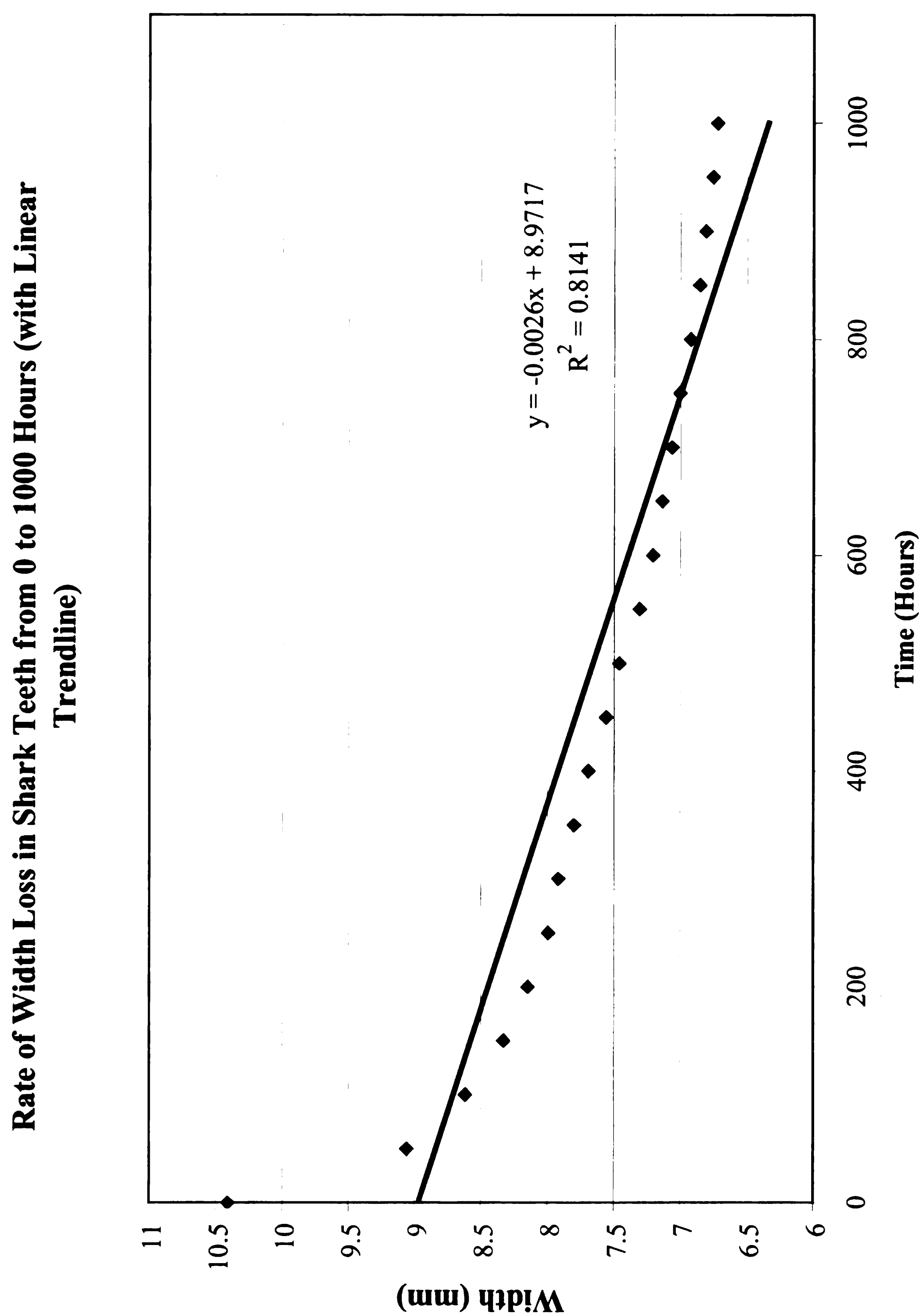
Appendix I continued: Data for correlation for ray (*Rhinoptera bonasus*) tooth mass loss.



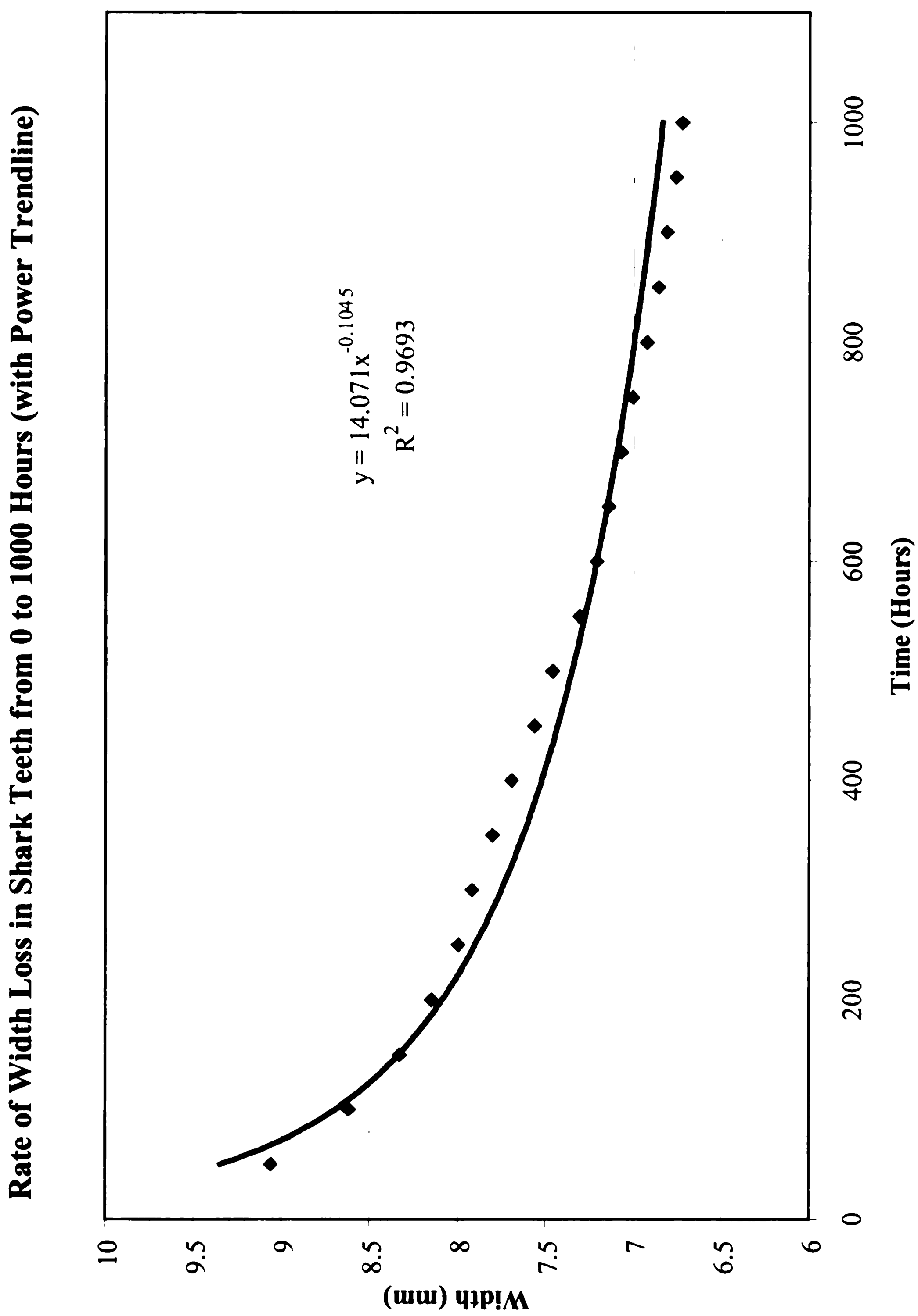
Appendix I continued: Rate of change in shark tooth height (Linear Regression).



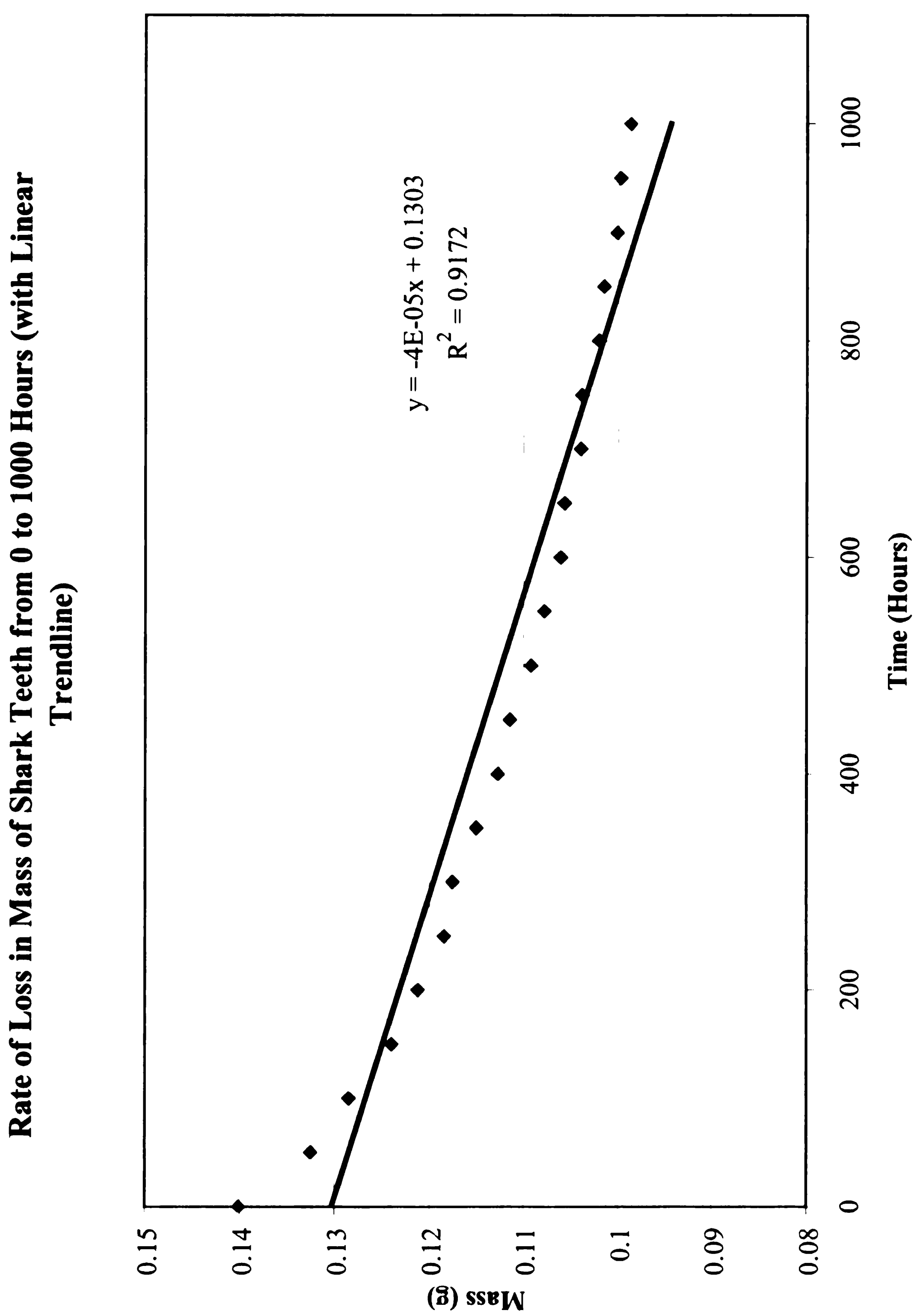
Appendix I continued: Rate of change in shark tooth height (Exponential Regression).



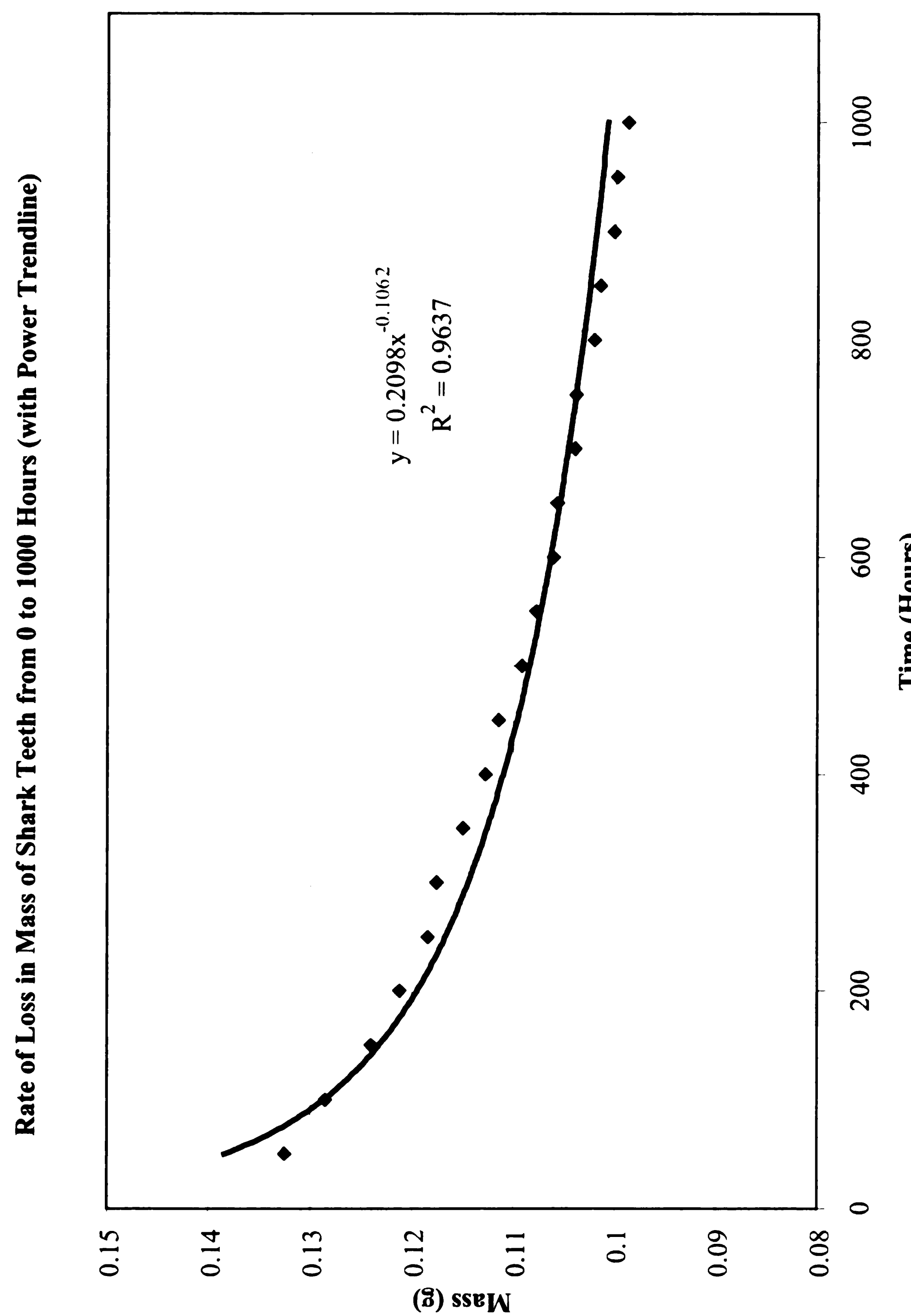
Appendix I continued: Rate of change in shark tooth width (Linear Regression).



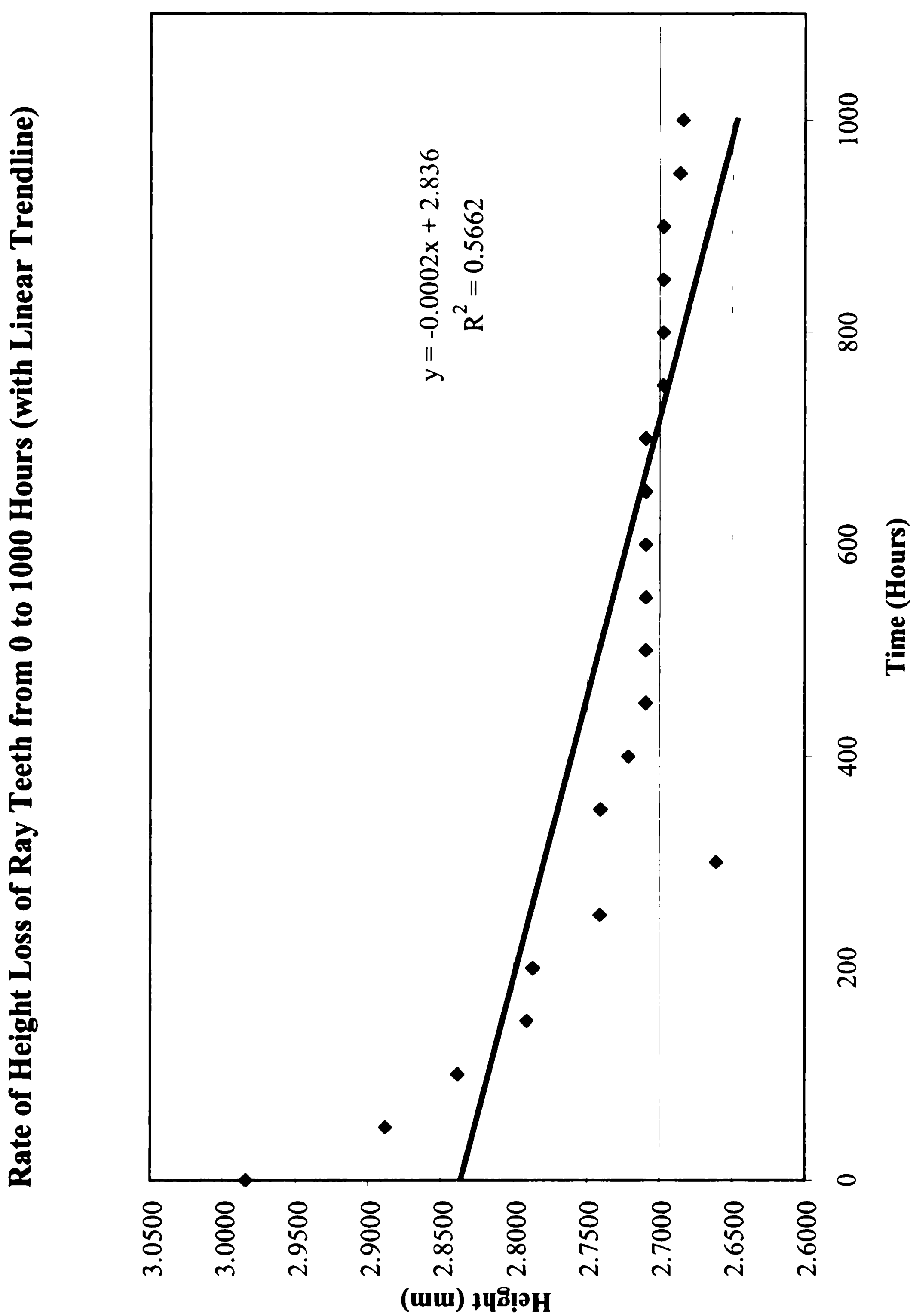
Appendix I continued: Rate of change in shark tooth width (Exponential Regression).



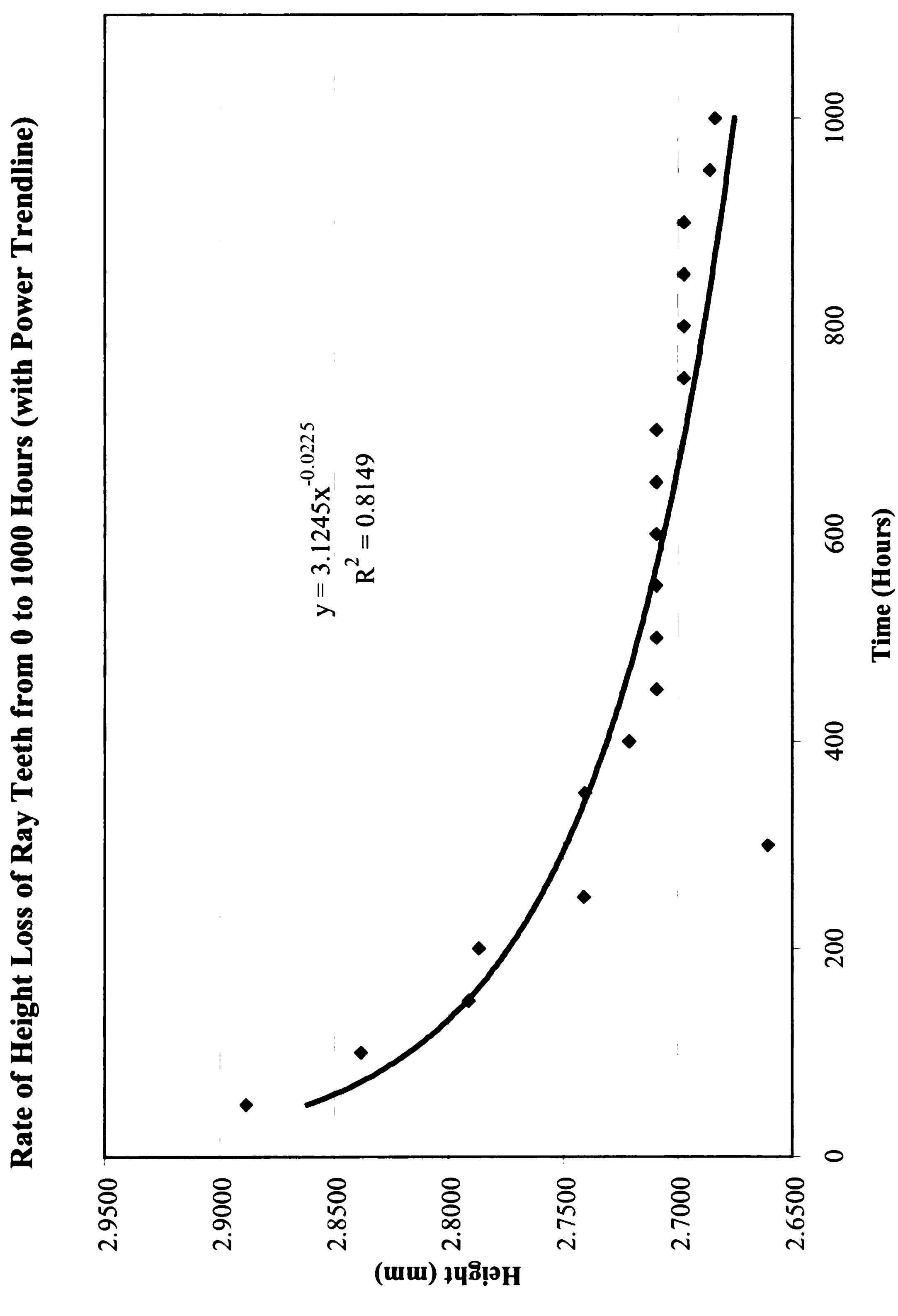
Appendix I continued: Rate of change in shark tooth mass (Linear Regression).



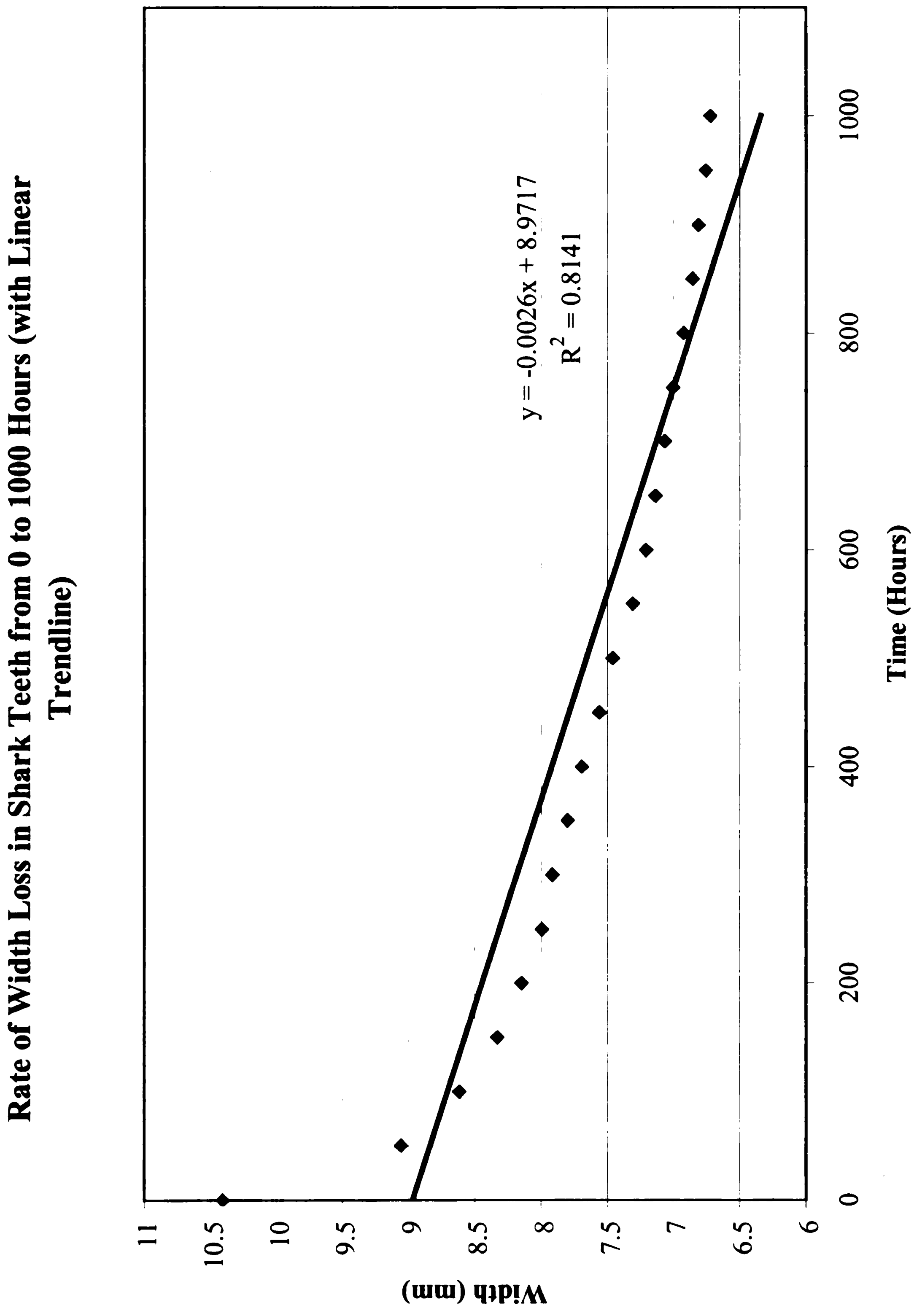
Appendix I continued: Rate of change in shark tooth mass (Exponential Regression).



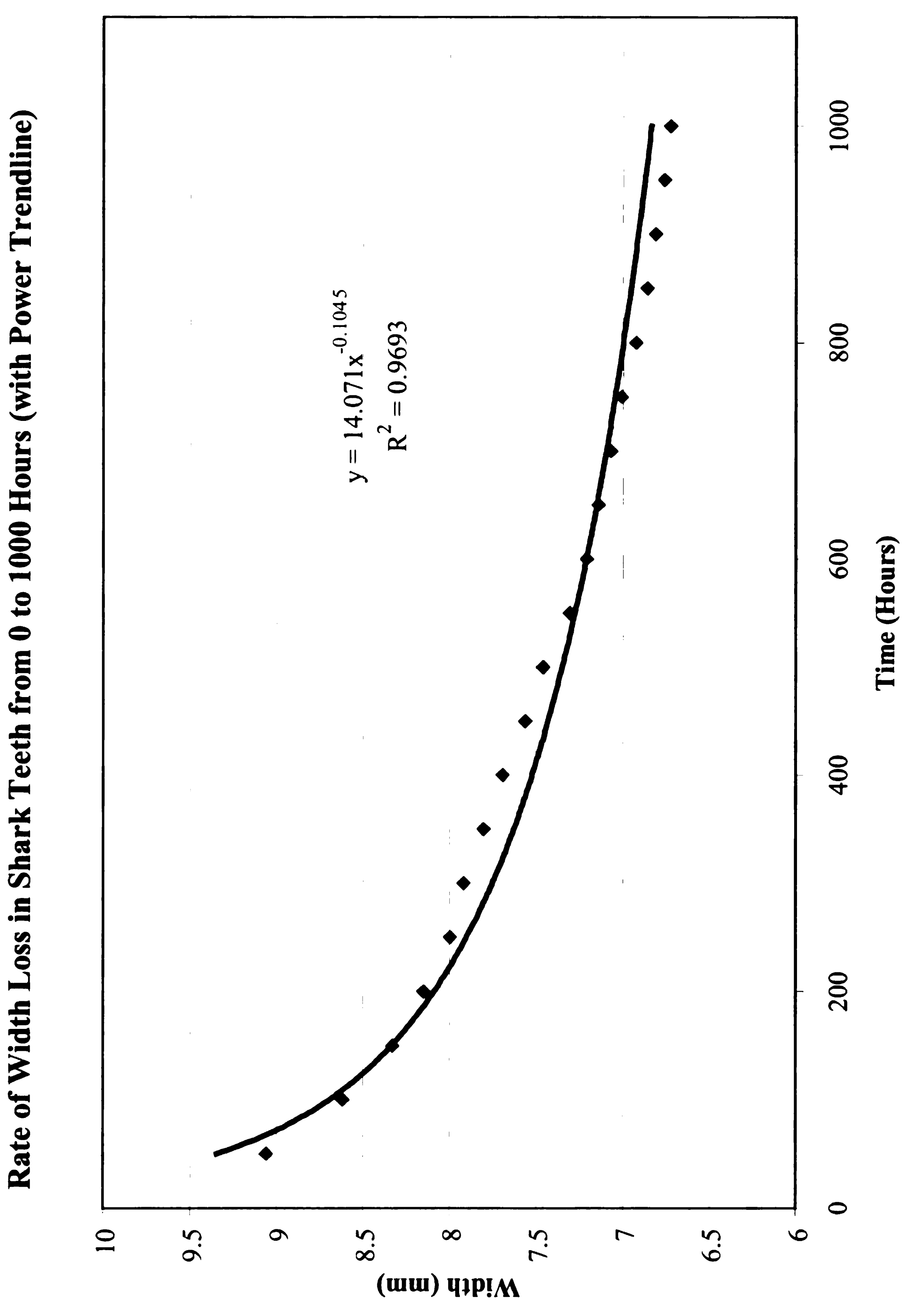
Appendix I continued: Rate of change in ray tooth height (Linear Regression).



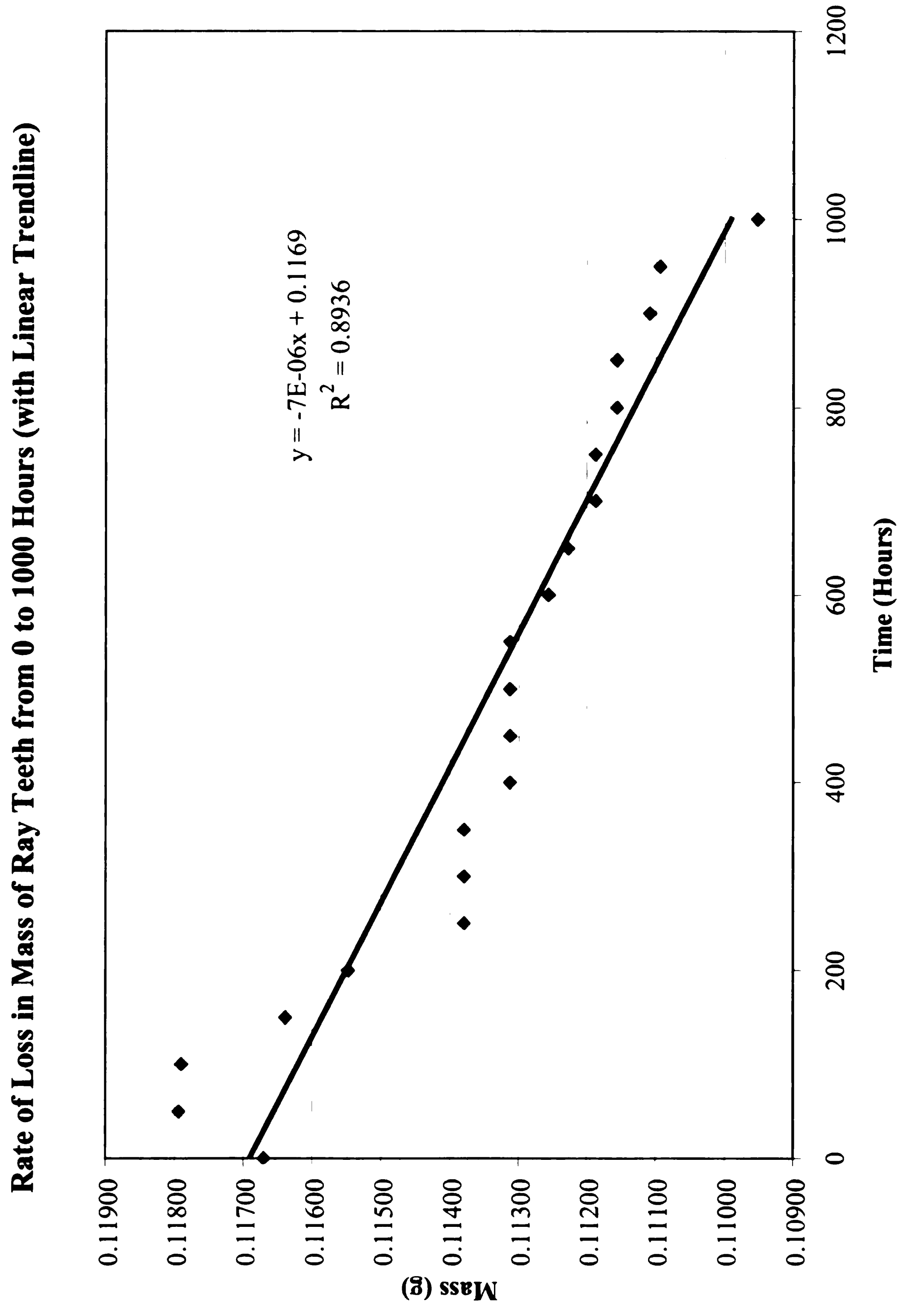
Appendix I continued: Rate of change in ray tooth height (Exponential Regression).



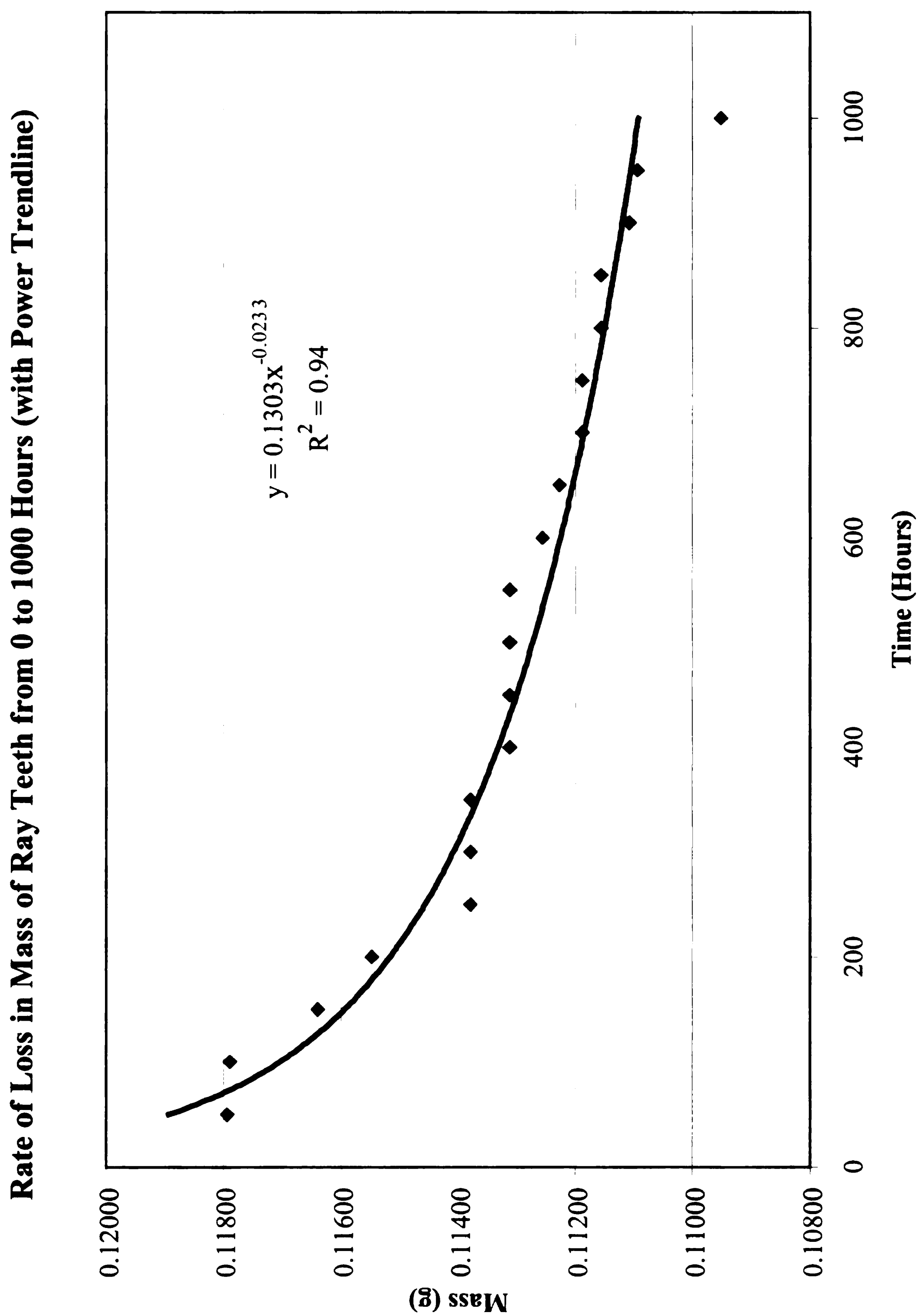
Appendix I continued: Rate of change in ray tooth width (Linear Regression).



Appendix I continued: Rate of change in ray tooth width (Exponential Regression).



Appendix I continued: Rate of change in ray tooth mass (Linear Regression).



Appendix I continued: Rate of change in ray tooth mass (Exponential Regression).

APPENDIX J

STUDENT'S t-TEST RESULTS FOR TOOTH HEIGHT, WIDTH, AND MASS LOSS

Height Shark

t-Test: Paired Two Sample for Means

	0 Hours	*50 Hours*
Mean	14.42472222	13.25986111
Variance	9.335265137	7.228397564
Observations	24	24
Pearson Correlation	0.991143656	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.78368613	
P(T<=t) one-tail	9.03664E-11	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.80733E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*100 Hours*
Mean	14.42472222	12.82006944
Variance	9.335265137	6.672043352
Observations	24	24
Pearson Correlation	0.983003775	
Hypothesized Mean Difference	0	
df	23	
t Stat	11.2145189	
P(T<=t) one-tail	4.21472E-11	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	8.42944E-11	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*150 Hours*
Mean	14.42472222	12.52201389
Variance	9.335265137	6.131723425
Observations	24	24
Pearson Correlation	0.980859681	
Hypothesized Mean Difference	0	
df	23	
t Stat	11.79045679	
P(T<=t) one-tail	1.56939E-11	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	3.13878E-11	
t Critical two-tail	2.068654794	

Appendix J: Student's t-Test results for tooth height, width, and mass loss.

Height Shark

t-Test: Paired Two Sample for Means

	0 Hours	*200 Hours*
Mean	14.42472222	12.33465278
Variance	9.335265137	5.834283087
Observations	24	24
Pearson Correlation	0.979668783	
Hypothesized Mean Difference	0	
df	23	
t Stat	12.15501521	
P(T<=t) one-tail	8.54995E-12	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.70999E-11	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*250 Hours*
Mean	14.42472222	12.18743056
Variance	9.335265137	5.734098787
Observations	24	24
Pearson Correlation	0.979238728	
Hypothesized Mean Difference	0	
df	23	
t Stat	12.73773266	
P(T<=t) one-tail	3.32918E-12	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	6.65836E-12	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*300 Hours*
Mean	14.42472222	12.09701389
Variance	9.335265137	5.728634778
Observations	24	24
Pearson Correlation	0.977592035	
Hypothesized Mean Difference	0	
df	23	
t Stat	13.03046371	
P(T<=t) one-tail	2.0985E-12	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	4.197E-12	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Shark

t-Test: Paired Two Sample for Means

	0 Hours	*350 Hours*
Mean	14.42472222	11.96673611
Variance	9.335265137	5.638428135
Observations	24	24
Pearson Correlation	0.975601135	
Hypothesized Mean Difference	0	
df	23	
t Stat	13.31757818	
P(T<=t) one-tail	1.34485E-12	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.6897E-12	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*400 Hours*
Mean	14.42472222	11.85347222
Variance	9.335265137	5.577162299
Observations	24	24
Pearson Correlation	0.974171613	
Hypothesized Mean Difference	0	
df	23	
t Stat	13.63045103	
P(T<=t) one-tail	8.35164E-13	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.67033E-12	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*450 Hours*
Mean	14.42472222	11.73479167
Variance	9.335265137	5.46610394
Observations	24	24
Pearson Correlation	0.971420841	
Hypothesized Mean Difference	0	
df	23	
t Stat	13.71687701	
P(T<=t) one-tail	7.33294E-13	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.46659E-12	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Shark

t-Test: Paired Two Sample for Means

	0 Hours	*500 Hours*
Mean	14.42472222	11.56357589
Variance	9.335265137	5.610436314
Observations	24	24
Pearson Correlation	0.961102276	
Hypothesized Mean Difference	0	
df	23	
t Stat	13.78026735	
P(T<=t) one-tail	6.66839E-13	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.33368E-12	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*550 Hours*
Mean	14.42472222	11.50270833
Variance	9.335265137	5.278741742
Observations	24	24
Pearson Correlation	0.967581222	
Hypothesized Mean Difference	0	
df	23	
t Stat	14.10874807	
P(T<=t) one-tail	4.09843E-13	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	8.19687E-13	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*600 Hours*
Mean	14.42472222	11.40895833
Variance	9.335265137	5.213785704
Observations	24	24
Pearson Correlation	0.968094302	
Hypothesized Mean Difference	0	
df	23	
t Stat	14.47919586	
P(T<=t) one-tail	2.39272E-13	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	4.78543E-13	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Shark

t-Test: Paired Two Sample for Means

	0 Hours	*650 Hours*
Mean	14.42472222	11.33611111
Variance	9.335265137	5.157293639
Observations	24	24
Pearson Correlation	0.966462418	
Hypothesized Mean Difference	0	
df	23	
t Stat	14.55518882	
P(T<=t) one-tail	2.14558E-13	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	4.29115E-13	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*700 Hours*
Mean	14.42472222	11.26194444
Variance	9.335265137	5.104538808
Observations	24	24
Pearson Correlation	0.965990562	
Hypothesized Mean Difference	0	
df	23	
t Stat	14.75171071	
P(T<=t) one-tail	1.62191E-13	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	3.24382E-13	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*750 Hours*
Mean	14.42472222	11.20055556
Variance	9.335265137	5.124993639
Observations	24	24
Pearson Correlation	0.96494317	
Hypothesized Mean Difference	0	
df	23	
t Stat	14.98212514	
P(T<=t) one-tail	1.17281E-13	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.34561E-13	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Shark

t-Test: Paired Two Sample for Means

	0 Hours	*800 Hours*
Mean	14.42472222	11.13069444
Variance	9.335265137	5.086656985
Observations	24	24
Pearson Correlation	0.965335001	
Hypothesized Mean Difference	0	
df	23	
t Stat	15.26367257	
P(T<=t) one-tail	7.93556E-14	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.58711E-13	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*850 Hours*
Mean	14.42472222	11.06902778
Variance	9.335265137	5.049366405
Observations	24	24
Pearson Correlation	0.964696855	
Hypothesized Mean Difference	0	
df	23	
t Stat	15.4099223	
P(T<=t) one-tail	6.49341E-14	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.29868E-13	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*900 Hours*
Mean	14.42472222	11.03305556
Variance	9.335265137	5.062119243
Observations	24	24
Pearson Correlation	0.964282244	
Hypothesized Mean Difference	0	
df	23	
t Stat	15.56324915	
P(T<=t) one-tail	5.27093E-14	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.05419E-13	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Shark

t-Test: Paired Two Sample for Means

	0 Hours	*950 Hours*
Mean	14.42472222	10.98604167
Variance	9.335265137	5.046448022
Observations	24	24
Pearson Correlation	0.965241596	
Hypothesized Mean Difference	0	
df	23	
t Stat	15.83676988	
P(T<=t) one-tail	3.64859E-14	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	7.29719E-14	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*1000 Hours*
Mean	14.42472222	10.9475
Variance	9.335265137	5.03429686
Observations	24	24
Pearson Correlation	0.966171238	
Hypothesized Mean Difference	0	
df	23	
t Stat	16.07788018	
P(T<=t) one-tail	2.64974E-14	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	5.29947E-14	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Shark - between intervals

t-Test: Paired Two Sample for Means

	50 Hours	*100 Hours*
Mean	13.25986111	12.82006944
Variance	7.228397564	6.672043352
Observations	24	24
Pearson Correlation	0.997659551	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.31295088	
P(T<=t) one-tail	2.1303E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	4.26061E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	100 Hours	*150 Hours*
Mean	12.82006944	12.52201389
Variance	6.672043352	6.131723425
Observations	24	24
Pearson Correlation	0.999145145	
Hypothesized Mean Difference	0	
df	23	
t Stat	9.768930379	
P(T<=t) one-tail	5.93051E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.1861E-09	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	150 Hours	*200 Hours*
Mean	12.52201389	12.33465278
Variance	6.131723425	5.834283087
Observations	24	24
Pearson Correlation	0.999228131	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.071881762	
P(T<=t) one-tail	1.83885E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	3.67769E-08	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Shark - between intervals

t-Test: Paired Two Sample for Means

	200 Hours	*250 Hours*
Mean	12.33465278	12.18743056
Variance	5.834283087	5.734098787
Observations	24	24
Pearson Correlation	0.999782201	
Hypothesized Mean Difference	0	
df	23	
t Stat	13.27165624	
P(T<=t) one-tail	1.44332E-12	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.88663E-12	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	250 Hours	*300 Hours*
Mean	12.18743056	12.09701389
Variance	5.734098787	5.728634778
Observations	24	24
Pearson Correlation	0.999696246	
Hypothesized Mean Difference	0	
df	23	
t Stat	7.505297101	
P(T<=t) one-tail	6.298E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.2596E-07	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	300 Hours	*350 Hours*
Mean	12.09701389	11.96673611
Variance	5.728634778	5.638428135
Observations	24	24
Pearson Correlation	0.999783357	
Hypothesized Mean Difference	0	
df	23	
t Stat	12.01757087	
P(T<=t) one-tail	1.07328E-11	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.14657E-11	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Shark - between intervals

t-Test: Paired Two Sample for Means

	350 Hours	*400 Hours*
Mean	11.96673611	11.85347222
Variance	5.638428135	5.577162299
Observations	24	24
Pearson Correlation	0.999752138	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.22094424	
P(T<=t) one-tail	2.5267E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	5.0534E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	400 Hours	*450 Hours*
Mean	11.85347222	11.73479167
Variance	5.577162299	5.46610394
Observations	24	24
Pearson Correlation	0.999766279	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.37681683	
P(T<=t) one-tail	1.89345E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	3.78689E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	450 Hours	*500 Hours*
Mean	11.73479167	11.56357589
Variance	5.46610394	5.610436314
Observations	24	24
Pearson Correlation	0.988495651	
Hypothesized Mean Difference	0	
df	23	
t Stat	2.341197208	
P(T<=t) one-tail	0.0141273	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.0282546	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Shark - between intervals

t-Test: Paired Two Sample for Means

	500 Hours	*550 Hours*
Mean	11.63680556	11.50270833
Variance	5.336017854	5.278741742
Observations	24	24
Pearson Correlation	0.999798673	
Hypothesized Mean Difference	0	
df	23	
t Stat	13.72339613	
P(T<=t) one-tail	7.26153E-13	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.45231E-12	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	550 Hours	*600 Hours*
Mean	11.50270833	11.40895833
Variance	5.278741742	5.213785704
Observations	24	24
Pearson Correlation	0.999838349	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.54446883	
P(T<=t) one-tail	1.39274E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.78549E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	600 Hours	*650 Hours*
Mean	11.40895833	11.33611111
Variance	5.213785704	5.157293639
Observations	24	24
Pearson Correlation	0.999936451	
Hypothesized Mean Difference	0	
df	23	
t Stat	12.51685826	
P(T<=t) one-tail	4.74141E-12	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	9.48282E-12	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Shark - between intervals

t-Test: Paired Two Sample for Means

	650 Hours	*700 Hours*
Mean	11.33611111	11.26194444
Variance	5.157293639	5.104538808
Observations	24	24
Pearson Correlation	0.9998999	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.65519762	
P(T<=t) one-tail	1.13909E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.27817E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	700 Hours	*750 Hours*
Mean	11.26194444	11.20055556
Variance	5.104538808	5.124993639
Observations	24	24
Pearson Correlation	0.999926588	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.82806294	
P(T<=t) one-tail	8.34584E-11	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.66917E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	750 Hours	*800 Hours*
Mean	11.20055556	11.13069444
Variance	5.124993639	5.086656985
Observations	24	24
Pearson Correlation	0.999935756	
Hypothesized Mean Difference	0	
df	23	
t Stat	12.68456739	
P(T<=t) one-tail	3.6234E-12	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	7.2468E-12	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Shark - between intervals

t-Test: Paired Two Sample for Means

	800 Hours	*850 Hours*
Mean	11.13069444	11.06902778
Variance	5.086656985	5.049366405
Observations	24	24
Pearson Correlation	0.999840621	
Hypothesized Mean Difference	0	
df	23	
t Stat	7.361690856	
P(T<=t) one-tail	8.66292E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.73258E-07	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	850 Hours	*900 Hours*
Mean	11.06902778	11.03305556
Variance	5.049366405	5.062119243
Observations	24	24
Pearson Correlation	0.99994208	
Hypothesized Mean Difference	0	
df	23	
t Stat	7.232517312	
P(T<=t) one-tail	1.1567E-07	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.31339E-07	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	900 Hours	*950 Hours*
Mean	11.03305556	10.98604167
Variance	5.062119243	5.046448022
Observations	24	24
Pearson Correlation	0.999952289	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.3579845	
P(T<=t) one-tail	1.96031E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	3.92062E-10	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Shark - between intervals

t-Test: Paired Two Sample for Means

	950 Hours	*1000 Hours*
Mean	10.98604167	10.9475
Variance	5.046448022	5.03429686
Observations	24	24
Pearson Correlation	0.999885753	
Hypothesized Mean Difference	0	
df	23	
t Stat	5.546155195	
P(T<=t) one-tail	6.08091E-06	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.21618E-05	
t Critical two-tail	2.068654794	

Appendix J continued.

Height Rays

t-Test: Paired Two Sample for Means

	0 Hours	*50 Hours*
Mean	2.984375	2.888333333
Variance	0.424008681	0.413585714
Observations	8	8
Pearson Correlation	0.990558758	
Hypothesized Mean Difference	0	
df	7	
t Stat	3.042400156	
P(T<=t) one-tail	0.009391632	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.018783265	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*100 Hours*
Mean	2.984375	2.838333333
Variance	0.424008681	0.412840476
Observations	8	8
Pearson Correlation	0.990921268	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.716122262	
P(T<=t) one-tail	0.001083664	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.002167329	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*150 Hours*
Mean	2.984375	2.79125
Variance	0.424008681	0.383523611
Observations	8	8
Pearson Correlation	0.995653534	
Hypothesized Mean Difference	0	
df	7	
t Stat	8.123947243	
P(T<=t) one-tail	4.13077E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	8.26155E-05	
t Critical two-tail	2.36462256	

Appendix J continued.

Height Rays

t-Test: Paired Two Sample for Means

	0 Hours	*200 Hours*
Mean	2.984375	2.786875
Variance	0.424008681	0.380342411
Observations	8	8
Pearson Correlation	0.99415066	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.282342073	
P(T<=t) one-tail	8.26266E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000165253	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*250 Hours*
Mean	2.984375	2.741041667
Variance	0.424008681	0.368207887
Observations	8	8
Pearson Correlation	0.99130697	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.321275687	
P(T<=t) one-tail	7.99073E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000159815	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*300 Hours*
Mean	2.984375	2.740625
Variance	0.424008681	0.367681696
Observations	8	8
Pearson Correlation	0.9913962	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.34909048	
P(T<=t) one-tail	7.80263E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000156053	
t Critical two-tail	2.36462256	

Appendix J continued.

Height Rays

t-Test: Paired Two Sample for Means

	0 Hours	*350 Hours*
Mean	2.984375	2.740625
Variance	0.424008681	0.367681696
Observations	8	8
Pearson Correlation	0.9913962	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.34909048	
P(T<=t) one-tail	7.80263E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000156053	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*400 Hours*
Mean	2.984375	2.721458333
Variance	0.424008681	0.364554315
Observations	8	8
Pearson Correlation	0.988295183	
Hypothesized Mean Difference	0	
df	7	
t Stat	6.950150934	
P(T<=t) one-tail	0.000110582	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000221164	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*450 Hours*
Mean	2.984375	2.709583333
Variance	0.424008681	0.364091071
Observations	8	8
Pearson Correlation	0.989147536	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.475740863	
P(T<=t) one-tail	7.00693E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000140139	
t Critical two-tail	2.36462256	

Appendix J continued.

Height Rays

t-Test: Paired Two Sample for Means

	0 Hours	*500 Hours*
Mean	2.984375	2.709583333
Variance	0.424008681	0.364091071
Observations	8	8
Pearson Correlation	0.989147536	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.475740863	
P(T<=t) one-tail	7.00693E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000140139	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*550 Hours*
Mean	2.984375	2.709583333
Variance	0.424008681	0.364091071
Observations	8	8
Pearson Correlation	0.989147536	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.475740863	
P(T<=t) one-tail	7.00693E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000140139	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*600 Hours*
Mean	2.984375	2.709583333
Variance	0.424008681	0.364091071
Observations	8	8
Pearson Correlation	0.989147536	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.475740863	
P(T<=t) one-tail	7.00693E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000140139	
t Critical two-tail	2.36462256	

Appendix J continued.

Height Rays

t-Test: Paired Two Sample for Means

	0 Hours	*650 Hours*
Mean	2.984375	2.709583333
Variance	0.424008681	0.364091071
Observations	8	8
Pearson Correlation	0.989147536	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.475740863	
P(T<=t) one-tail	7.00693E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000140139	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*700 Hours*
Mean	2.984375	2.709583333
Variance	0.424008681	0.364091071
Observations	8	8
Pearson Correlation	0.989147536	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.475740863	
P(T<=t) one-tail	7.00693E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000140139	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*750 Hours*
Mean	2.984375	2.709583333
Variance	0.424008681	0.364091071
Observations	8	8
Pearson Correlation	0.989147536	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.475740863	
P(T<=t) one-tail	7.00693E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000140139	
t Critical two-tail	2.36462256	

Appendix J continued.

Height Rays

t-Test: Paired Two Sample for Means

	0 Hours	*800 Hours*
Mean	2.984375	2.6975
Variance	0.424008681	0.362355556
Observations	8	8
Pearson Correlation	0.988990882	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.718521866	
P(T<=t) one-tail	5.72447E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000114489	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*850 Hours*
Mean	2.984375	2.6975
Variance	0.424008681	0.362355556
Observations	8	8
Pearson Correlation	0.988990882	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.718521866	
P(T<=t) one-tail	5.72447E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000114489	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*900 Hours*
Mean	2.984375	2.6975
Variance	0.424008681	0.362355556
Observations	8	8
Pearson Correlation	0.988990882	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.718521866	
P(T<=t) one-tail	5.72447E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000114489	
t Critical two-tail	2.36462256	

Appendix J continued.

Height Rays

t-Test: Paired Two Sample for Means

	0 Hours	*950 Hours*
Mean	2.984375	2.68625
Variance	0.424008681	0.362194246
Observations	8	8
Pearson Correlation	0.988404801	
Hypothesized Mean Difference	0	
df	7	
t Stat	7.855678114	
P(T<=t) one-tail	5.1183E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000102366	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*1000 Hours*
Mean	2.984375	2.683958333
Variance	0.424008681	0.368257887
Observations	8	8
Pearson Correlation	0.988580703	
Hypothesized Mean Difference	0	
df	7	
t Stat	8.10580303	
P(T<=t) one-tail	4.19032E-05	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	8.38064E-05	
t Critical two-tail	2.36462256	

Appendix J continued.

Height Rays - between intervals

t-Test: Paired Two Sample for Means

	50 Hours	*100 Hours*
Mean	2.888333333	2.838333333
Variance	0.413585714	0.412840476
Observations	8	8
Pearson Correlation	0.998205529	
Hypothesized Mean Difference	0	
df	7	
t Stat	3.671940368	
P(T<=t) one-tail	0.003971919	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.007943838	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	100 Hours	*150 Hours*
Mean	2.838333333	2.79125
Variance	0.412840476	0.383523611
Observations	8	8
Pearson Correlation	0.996803165	
Hypothesized Mean Difference	0	
df	7	
t Stat	2.398059972	
P(T<=t) one-tail	0.023800822	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.047601645	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	150 Hours	*200 Hours*
Mean	2.79125	2.786875
Variance	0.383523611	0.380342411
Observations	8	8
Pearson Correlation	0.999869511	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.200209968	
P(T<=t) one-tail	0.134547724	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.269095447	
t Critical two-tail	2.36462256	

Appendix J continued.

Height Rays - between intervals

t-Test: Paired Two Sample for Means

	200 Hours	*250 Hours*
Mean	2.786875	2.741041667
Variance	0.380342411	0.368207887
Observations	8	8
Pearson Correlation	0.998708376	
Hypothesized Mean Difference	0	
df	7	
t Stat	3.972239737	
P(T<=t) one-tail	0.002688449	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.005376898	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	250 Hours	*300 Hours*
Mean	2.741041667	2.740625
Variance	0.368207887	0.367681696
Observations	8	8
Pearson Correlation	0.999998368	
Hypothesized Mean Difference	0	
df	7	
t Stat	1	
P(T<=t) one-tail	0.175308331	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.350616663	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	300 Hours	*350 Hours*
Mean	2.740625	2.740625
Variance	0.367681696	0.367681696
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

Appendix J continued.

Height Rays - between intervals

t-Test: Paired Two Sample for Means

	350 Hours	*400 Hours*
Mean	2.740625	2.721458333
Variance	0.367681696	0.364554315
Observations	8	8
Pearson Correlation	0.999048801	
Hypothesized Mean Difference	0	
df	7	
t Stat	2.044372334	
P(T<=t) one-tail	0.040096863	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.080193726	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	400 Hours	*450 Hours*
Mean	2.721458333	2.709583333
Variance	0.364554315	0.364091071
Observations	8	8
Pearson Correlation	0.99931461	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.50275291	
P(T<=t) one-tail	0.088302273	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.176604546	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	450 Hours	*500 Hours*
Mean	2.709583333	2.709583333
Variance	0.364091071	0.364091071
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

Appendix J continued.

Height Rays - between intervals

t-Test: Paired Two Sample for Means

	500 Hours	*550 Hours*
Mean	2.709583333	2.709583333
Variance	0.364091071	0.364091071
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	550 Hours	*600 Hours*
Mean	2.709583333	2.709583333
Variance	0.364091071	0.364091071
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	600 Hours	*650 Hours*
Mean	2.709583333	2.709583333
Variance	0.364091071	0.364091071
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

Appendix J continued.

Height Rays - between intervals

t-Test: Paired Two Sample for Means

	650 Hours	*700 Hours*
Mean	2.709583333	2.709583333
Variance	0.364091071	0.364091071
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	700 Hours	*750 Hours*
Mean	2.709583333	2.6975
Variance	0.364091071	0.362355556
Observations	8	8
Pearson Correlation	0.999099618	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.334227601	
P(T<=t) one-tail	0.111948546	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.223897093	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	750 Hours	*800 Hours*
Mean	2.6975	2.6975
Variance	0.362355556	0.362355556
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

Appendix J continued.

Height Rays - between intervals

t-Test: Paired Two Sample for Means

	800 Hours	*850 Hours*
Mean	2.6975	2.6975
Variance	0.362355556	0.362355556
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	850 Hours	*900 Hours*
Mean	2.6975	2.6975
Variance	0.362355556	0.362355556
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	900 Hours	*950 Hours*
Mean	2.68625	2.683958333
Variance	0.362194246	0.368257887
Observations	8	8
Pearson Correlation	0.999976937	
Hypothesized Mean Difference	0	
df	7	
t Stat	1	
P(T<=t) one-tail	0.175308331	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.350616663	
t Critical two-tail	2.36462256	

Appendix J continued.

Height Rays - between intervals

t-Test: Paired Two Sample for Means

	950 Hours	*1000 hOurs*
Mean	2.68625	2.683958333
Variance	0.362194246	0.368257887
Observations	8	8
Pearson Correlation	0.999976937	
Hypothesized Mean Difference	0	
df	7	
t Stat	1	
P(T<=t) one-tail	0.175308331	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.350616663	
t Critical two-tail	2.36462256	

Appendix J continued.

Width Shark

t-Test: Paired Two Sample for Means

	0 Hours	*50 Hours*
Mean	10.40888889	9.060625
Variance	8.492985668	5.920836428
Observations	24	24
Pearson Correlation	0.983082201	
Hypothesized Mean Difference	0	
df	23	
t Stat	9.621327058	
P(T<=t) one-tail	7.87855E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.57571E-09	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*100 Hours*
Mean	10.40888889	8.61875
Variance	8.492985668	5.108666002
Observations	24	24
Pearson Correlation	0.969316997	
Hypothesized Mean Difference	0	
df	23	
t Stat	9.614711073	
P(T<=t) one-tail	7.98E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.596E-09	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*150 Hours*
Mean	10.40888889	8.330416667
Variance	8.492985668	4.807842331
Observations	24	24
Pearson Correlation	0.959008614	
Hypothesized Mean Difference	0	
df	23	
t Stat	9.962780527	
P(T<=t) one-tail	4.10074E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	8.20148E-10	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark

t-Test: Paired Two Sample for Means

	0 Hours	*200 Hours*
Mean	10.40888889	8.14875
Variance	8.492985668	4.555733877
Observations	24	24
Pearson Correlation	0.953181126	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.14735147	
P(T<=t) one-tail	2.89834E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	5.79668E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*250 Hours*
Mean	10.40888889	7.994930556
Variance	8.492985668	4.521053256
Observations	24	24
Pearson Correlation	0.948795624	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.55416363	
P(T<=t) one-tail	1.36837E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.73673E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*300 Hours*
Mean	10.40888889	7.916388889
Variance	8.492985668	4.428409098
Observations	24	24
Pearson Correlation	0.944575772	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.5652803	
P(T<=t) one-tail	1.34095E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.68191E-10	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark

t-Test: Paired Two Sample for Means

	0 Hours	*350 Hours*
Mean	10.40888889	7.800277778
Variance	8.492985668	4.319716586
Observations	24	24
Pearson Correlation	0.940520981	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.7272747	
P(T<=t) one-tail	1.00012E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.00024E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*400 Hours*
Mean	10.40888889	7.693958333
Variance	8.492985668	4.213189085
Observations	24	24
Pearson Correlation	0.937110579	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.87837292	
P(T<=t) one-tail	7.62839E-11	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.52568E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*450 Hours*
Mean	10.40888889	7.561597222
Variance	8.492985668	4.037218473
Observations	24	24
Pearson Correlation	0.928554409	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.8403714	
P(T<=t) one-tail	8.16409E-11	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.63282E-10	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark

t-Test: Paired Two Sample for Means

	0 Hours	*500 Hours*
Mean	10.40888889	7.459027778
Variance	8.492985668	3.933991767
Observations	24	24
Pearson Correlation	0.921772321	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.85975003	
P(T<=t) one-tail	7.88621E-11	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.57724E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*550 Hours*
Mean	10.40888889	7.306041667
Variance	8.492985668	3.795988361
Observations	24	24
Pearson Correlation	0.901530911	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.61344307	
P(T<=t) one-tail	1.2286E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.4572E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*600 Hours*
Mean	10.40888889	7.208888889
Variance	8.492985668	3.686559823
Observations	24	24
Pearson Correlation	0.889961423	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.52167085	
P(T<=t) one-tail	1.45186E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.90372E-10	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark

t-Test: Paired Two Sample for Means

	0 Hours	*650 Hours*
Mean	10.40888889	7.139513889
Variance	8.492985668	3.657497459
Observations	24	24
Pearson Correlation	0.88067207	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.4843625	
P(T<=t) one-tail	1.55427E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	3.10854E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*700 Hours*
Mean	10.40888889	7.069027778
Variance	8.492985668	3.565205052
Observations	24	24
Pearson Correlation	0.874768202	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.49381374	
P(T<=t) one-tail	1.52764E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	3.05528E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*750 Hours*
Mean	10.40888889	7.00625
Variance	8.492985668	3.52300465
Observations	24	24
Pearson Correlation	0.867725567	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.49435193	
P(T<=t) one-tail	1.52614E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	3.05228E-10	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark

t-Test: Paired Two Sample for Means

	0 Hours	*800 Hours*
Mean	10.40888889	6.925763889
Variance	8.492985668	3.486685261
Observations	24	24
Pearson Correlation	0.859487964	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.53102301	
P(T<=t) one-tail	1.4273E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.85461E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*850 Hours*
Mean	10.40888889	6.857916667
Variance	8.492985668	3.418302717
Observations	24	24
Pearson Correlation	0.85572659	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.6069853	
P(T<=t) one-tail	1.24308E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.48616E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*900 Hours*
Mean	10.40888889	6.81125
Variance	8.492985668	3.431906341
Observations	24	24
Pearson Correlation	0.851990979	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.67594846	
P(T<=t) one-tail	1.09714E-10	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.19428E-10	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark

t-Test: Paired Two Sample for Means

	0 Hours	*950 Hours*
Mean	10.40888889	6.757694444
Variance	8.492985668	3.461402598
Observations	24	24
Pearson Correlation	0.847893664	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.76698321	
P(T<=t) one-tail	9.31176E-11	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.86235E-10	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*1000 Hours*
Mean	10.40888889	6.724569444
Variance	8.492985668	3.425890826
Observations	24	24
Pearson Correlation	0.845040372	
Hypothesized Mean Difference	0	
df	23	
t Stat	10.78185769	
P(T<=t) one-tail	9.06635E-11	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.81327E-10	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark - between intervals

t-Test: Paired Two Sample for Means

	50 Hours	*100 Hours*
Mean	9.060625	8.61875
Variance	5.920836428	5.108666002
Observations	24	24
Pearson Correlation	0.997197682	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.781515775	
P(T<=t) one-tail	4.17916E-09	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	8.35832E-09	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	100 Hours	*150 Hours*
Mean	8.61875	8.330416667
Variance	5.108666002	4.807842331
Observations	24	24
Pearson Correlation	0.996858022	
Hypothesized Mean Difference	0	
df	23	
t Stat	7.475216277	
P(T<=t) one-tail	6.73143E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.34629E-07	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	150 Hours	*200 Hours*
Mean	8.330416667	8.14875
Variance	4.807842331	4.555733877
Observations	24	24
Pearson Correlation	0.999025614	
Hypothesized Mean Difference	0	
df	23	
t Stat	7.955470333	
P(T<=t) one-tail	2.35981E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	4.71963E-08	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark - between intervals

t-Test: Paired Two Sample for Means

	200 Hours	*250 Hours*
Mean	8.14875	7.994930556
Variance	4.555733877	4.521053256
Observations	24	24
Pearson Correlation	0.999127614	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.433128779	
P(T<=t) one-tail	8.57759E-09	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.71552E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	250 Hours	*300 Hours*
Mean	7.994930556	7.916388889
Variance	4.521053256	4.428409098
Observations	24	24
Pearson Correlation	0.999513559	
Hypothesized Mean Difference	0	
df	23	
t Stat	5.534922273	
P(T<=t) one-tail	6.24994E-06	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.24999E-05	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	300 Hours	*350 Hours*
Mean	7.916388889	7.800277778
Variance	4.428409098	4.319716586
Observations	24	24
Pearson Correlation	0.999080254	
Hypothesized Mean Difference	0	
df	23	
t Stat	6.091214833	
P(T<=t) one-tail	1.6309E-06	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	3.2618E-06	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark - between intervals

t-Test: Paired Two Sample for Means

	350 Hours	*400 Hours*
Mean	7.800277778	7.693958333
Variance	4.319716586	4.213189085
Observations	24	24
Pearson Correlation	0.999463815	
Hypothesized Mean Difference	0	
df	23	
t Stat	7.195465421	
P(T<=t) one-tail	1.25721E-07	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.51443E-07	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	400 Hours	*450 Hours*
Mean	7.693958333	7.561597222
Variance	4.213189085	4.037218473
Observations	24	24
Pearson Correlation	0.998969781	
Hypothesized Mean Difference	0	
df	23	
t Stat	6.366195585	
P(T<=t) one-tail	8.49718E-07	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.69944E-06	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	450 Hours	*500 Hours*
Mean	7.561597222	7.459027778
Variance	4.037218473	3.933991767
Observations	24	24
Pearson Correlation	0.999174717	
Hypothesized Mean Difference	0	
df	23	
t Stat	5.90287135	
P(T<=t) one-tail	2.56128E-06	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	5.12257E-06	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark - between intervals

t-Test: Paired Two Sample for Means

	500 Hours	*550 Hours*
Mean	7.459027778	7.306041667
Variance	3.933991767	3.795988361
Observations	24	24
Pearson Correlation	0.995217162	
Hypothesized Mean Difference	0	
df	23	
t Stat	3.834785506	
P(T<=t) one-tail	0.000423582	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.000847165	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	550 Hours	*600 Hours*
Mean	7.306041667	7.208888889
Variance	3.795988361	3.686559823
Observations	24	24
Pearson Correlation	0.999107922	
Hypothesized Mean Difference	0	
df	23	
t Stat	5.505153401	
P(T<=t) one-tail	6.72134E-06	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.34427E-05	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	600 Hours	*650 Hours*
Mean	7.208888889	7.139513889
Variance	3.686559823	3.657497459
Observations	24	24
Pearson Correlation	0.999626013	
Hypothesized Mean Difference	0	
df	23	
t Stat	6.418224281	
P(T<=t) one-tail	7.51841E-07	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.50368E-06	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark - between intervals

t-Test: Paired Two Sample for Means

	650 Hours	*700 Hours*
Mean	7.139513889	7.069027778
Variance	3.657497459	3.565205052
Observations	24	24
Pearson Correlation	0.999796981	
Hypothesized Mean Difference	0	
df	23	
t Stat	7.615647279	
P(T<=t) one-tail	4.9387E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	9.8774E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	700 Hours	*750 Hours*
Mean	7.069027778	7.00625
Variance	3.565205052	3.52300465
Observations	24	24
Pearson Correlation	0.999727597	
Hypothesized Mean Difference	0	
df	23	
t Stat	6.781931651	
P(T<=t) one-tail	3.2252E-07	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	6.4504E-07	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	750 Hours	*800 Hours*
Mean	7.00625	6.925763889
Variance	3.52300465	3.486685261
Observations	24	24
Pearson Correlation	0.999026078	
Hypothesized Mean Difference	0	
df	23	
t Stat	4.739643018	
P(T<=t) one-tail	4.45375E-05	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	8.90749E-05	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark - between intervals

t-Test: Paired Two Sample for Means

	800 Hours	*850 Hours*
Mean	6.925763889	6.857916667
Variance	3.486685261	3.418302717
Observations	24	24
Pearson Correlation	0.999643431	
Hypothesized Mean Difference	0	
df	23	
t Stat	6.280760611	
P(T<=t) one-tail	1.03956E-06	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.07911E-06	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	850 Hours	*900 Hours*
Mean	6.857916667	6.81125
Variance	3.418302717	3.431906341
Observations	24	24
Pearson Correlation	0.999768931	
Hypothesized Mean Difference	0	
df	23	
t Stat	5.721958405	
P(T<=t) one-tail	3.96501E-06	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	7.93003E-06	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	900 Hours	*950 Hours*
Mean	6.81125	6.757694444
Variance	3.431906341	3.461402598
Observations	24	24
Pearson Correlation	0.999694995	
Hypothesized Mean Difference	0	
df	23	
t Stat	5.637971826	
P(T<=t) one-tail	4.86203E-06	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	9.72406E-06	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Shark - between intervals

t-Test: Paired Two Sample for Means

	950 Hours	*1000 Hours*
Mean	6.757694444	6.724569444
Variance	3.461402598	3.425890826
Observations	24	24
Pearson Correlation	0.999800116	
Hypothesized Mean Difference	0	
df	23	
t Stat	4.235163355	
P(T<=t) one-tail	0.00015667	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.00031334	
t Critical two-tail	2.068654794	

Appendix J continued.

Width Ray

t-Test: Paired Two Sample for Means

	0 Hours	*50 Hours*
Mean	12.585625	12.56854167
Variance	2.491400744	2.566210665
Observations	8	8
Pearson Correlation	0.99965888	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.012290577	
P(T<=t) one-tail	0.172551684	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.345103367	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*100 Hours*
Mean	12.585625	12.56854167
Variance	2.491400744	2.566210665
Observations	8	8
Pearson Correlation	0.99965888	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.012290577	
P(T<=t) one-tail	0.172551684	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.345103367	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*150 Hours*
Mean	12.585625	12.54083333
Variance	2.491400744	2.598220635
Observations	8	8
Pearson Correlation	0.999589819	
Hypothesized Mean Difference	0	
df	7	
t Stat	2.236690183	
P(T<=t) one-tail	0.030185986	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.060371973	
t Critical two-tail	2.36462256	

Appendix J continued.

Width Ray

t-Test: Paired Two Sample for Means

	0 Hours	*200 Hours*
Mean	12.585625	12.468125
Variance	2.491400744	2.602365427
Observations	8	8
Pearson Correlation	0.999030032	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.238394278	
P(T<=t) one-tail	0.001923971	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.003847943	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*250 Hours*
Mean	12.585625	12.43083333
Variance	2.491400744	2.607329365
Observations	8	8
Pearson Correlation	0.999076618	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.640476992	
P(T<=t) one-tail	0.000391097	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000782194	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*300 Hours*
Mean	12.585625	12.44041667
Variance	2.491400744	2.658828373
Observations	8	8
Pearson Correlation	0.999400924	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.390159973	
P(T<=t) one-tail	0.000509593	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001019187	
t Critical two-tail	2.36462256	

Appendix J continued.

Width Ray

t-Test: Paired Two Sample for Means

	0 Hours	*350 Hours*
Mean	12.585625	12.44041667
Variance	2.491400744	2.658828373
Observations	8	8
Pearson Correlation	0.999400924	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.390159973	
P(T<=t) one-tail	0.000509593	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001019187	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*400 Hours*
Mean	12.585625	12.44041667
Variance	2.491400744	2.658828373
Observations	8	8
Pearson Correlation	0.999400924	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.390159973	
P(T<=t) one-tail	0.000509593	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001019187	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*450 Hours*
Mean	12.585625	12.4375
Variance	2.491400744	2.642999206
Observations	8	8
Pearson Correlation	0.99932222	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.541007439	
P(T<=t) one-tail	0.000434049	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000868099	
t Critical two-tail	2.36462256	

Appendix J continued.

Width Ray

t-Test: Paired Two Sample for Means

	0 Hours	*500 Hours*
Mean	12.585625	12.43416667
Variance	2.491400744	2.625075397
Observations	8	8
Pearson Correlation	0.999210988	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.633724705	
P(T<=t) one-tail	0.000393858	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000787715	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 hours	*550 Hours*
Mean	12.585625	12.41041667
Variance	2.491400744	2.59645377
Observations	8	8
Pearson Correlation	0.99842624	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.197770493	
P(T<=t) one-tail	0.000628042	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001256084	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*600 Hours*
Mean	12.585625	12.41041667
Variance	2.491400744	2.59645377
Observations	8	8
Pearson Correlation	0.99842624	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.197770493	
P(T<=t) one-tail	0.000628042	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001256084	
t Critical two-tail	2.36462256	

Appendix J continued.

Width Ray

t-Test: Paired Two Sample for Means

	0 Hours	*650 Hours*
Mean	12.585625	12.41041667
Variance	2.491400744	2.59645377
Observations	8	8
Pearson Correlation	0.99842624	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.197770493	
P(T<=t) one-tail	0.000628042	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001256084	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*700 Hours*
Mean	12.585625	12.40458333
Variance	2.491400744	2.60455377
Observations	8	8
Pearson Correlation	0.998063835	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.855787909	
P(T<=t) one-tail	0.000922018	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001844037	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*750 Hours*
Mean	12.585625	12.40458333
Variance	2.491400744	2.60455377
Observations	8	8
Pearson Correlation	0.998063835	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.855787909	
P(T<=t) one-tail	0.000922018	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001844037	
t Critical two-tail	2.36462256	

Appendix J continued.

Width Ray

t-Test: Paired Two Sample for Means

	0 Hours	*800 Hours*
Mean	12.585625	12.40458333
Variance	2.491400744	2.60455377
Observations	8	8
Pearson Correlation	0.998063835	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.855787909	
P(T<=t) one-tail	0.000922018	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001844037	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*850 Hours*
Mean	12.585625	12.40458333
Variance	2.491400744	2.60455377
Observations	8	8
Pearson Correlation	0.998063835	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.855787909	
P(T<=t) one-tail	0.000922018	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001844037	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*900 Hours*
Mean	12.585625	12.40458333
Variance	2.491400744	2.60455377
Observations	8	8
Pearson Correlation	0.998063835	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.855787909	
P(T<=t) one-tail	0.000922018	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001844037	
t Critical two-tail	2.36462256	

Appendix J continued.

Width Ray

t-Test: Paired Two Sample for Means

	0 Hours	*950 Hours*
Mean	12.585625	12.40458333
Variance	2.491400744	2.60455377
Observations	8	8
Pearson Correlation	0.998063835	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.855787909	
P(T<=t) one-tail	0.000922018	
t.Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001844037	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*1000 Hours*
Mean	12.585625	12.39229167
Variance	2.491400744	2.643612649
Observations	8	8
Pearson Correlation	0.997343099	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.337504107	
P(T<=t) one-tail	0.001703223	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.003406446	
t Critical two-tail	2.36462256	

Appendix J continued.

Width Ray - between intervals

t-Test: Paired Two Sample for Means

	50 Hours	*100 Hours*
Mean	12.56854167	12.5685417
Variance	2.566210665	2.56621066
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	100 Hours	*150 Hours*
Mean	12.56854167	12.5408333
Variance	2.566210665	2.59822063
Observations	8	8
Pearson Correlation	0.999883674	
Hypothesized Mean Difference	0	
df	7	
t Stat	2.962250388	
P(T<=t) one-tail	0.010518881	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.021037762	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	150 Hours	*200 Hours*
Mean	12.54083333	12.468125
Variance	2.598220635	2.60236543
Observations	8	8
Pearson Correlation	0.99980331	
Hypothesized Mean Difference	0	
df	7	
t Stat	6.424833055	
P(T<=t) one-tail	0.000179359	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000358718	
t Critical two-tail	2.36462256	

Appendix J continued.

Width Ray - between intervals

t-Test: Paired Two Sample for Means

	200 Hours	*250 Hours*
Mean	12.468125	12.4404167
Variance	2.602365427	2.65882837
Observations	8	8
Pearson Correlation	0.999888339	
Hypothesized Mean Difference	0	
df	7	
t Stat	2.626372592	
P(T<=t) one-tail	0.017045938	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.034091876	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	250 Hours	*300 Hours*
Mean	12.44041667	12.4404167
Variance	2.658828373	2.65882837
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	300 Hours	*350 Hours*
Mean	12.44041667	12.4404167
Variance	2.658828373	2.65882837
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

Appendix J continued.

Width Ray - between intervals

t-Test: Paired Two Sample for Means

	350 Hours	*400 Hours*
Mean	12.44041667	12.4404167
Variance	2.658828373	2.65882837
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	400 Hours	*450 Hours*
Mean	12.44041667	12.4375
Variance	2.658828373	2.64299921
Observations	8	8
Pearson Correlation	0.999991621	
Hypothesized Mean Difference	0	
df	7	
t Stat	1	
P(T<=t) one-tail	0.175308331	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.350616663	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	450 Hours	*500 Hours*
Mean	12.4375	12.4341667
Variance	2.642999206	2.6250754
Observations	8	8
Pearson Correlation	0.999988915	
Hypothesized Mean Difference	0	
df	7	
t Stat	1	
P(T<=t) one-tail	0.175308331	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.350616663	
t Critical two-tail	2.36462256	

Appendix J continued.

Width Ray - between intervals

t-Test: Paired Two Sample for Means

	500 Hours	*550 Hours*
Mean	12.43416667	12.4104167
Variance	2.625075397	2.59645377
Observations	8	8
Pearson Correlation	0.999759553	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.839256587	
P(T<=t) one-tail	0.05423158	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.108463159	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	550 Hours	*600 Hours*
Mean	12.41041667	12.4104167
Variance	2.59645377	2.59645377
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	600 Hours	*650 Hours*
Mean	12.41041667	12.4104167
Variance	2.59645377	2.59645377
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

Appendix J continued.

Width Ray - between intervals

t-Test: Paired Two Sample for Means

	650 Hours	*700 Hours*
Mean	12.41041667	12.4045833
Variance	2.59645377	2.60455377
Observations	8	8
Pearson Correlation	0.999971304	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.322875656	
P(T<=t) one-tail	0.113726409	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.227452818	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	700 Hours	*750 Hours*
Mean	12.40458333	12.4045833
Variance	2.60455377	2.60455377
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	750 Hours	*800 Hours*
Mean	12.40458333	12.4045833
Variance	2.60455377	2.60455377
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

Appendix J continued.

Width Ray - between intervals

t-Test: Paired Two Sample for Means

	800 Hours	*850 Hours*
Mean	12.40458333	12.4045833
Variance	2.60455377	2.60455377
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	850 Hours	*900 Hours*
Mean	12.40458333	12.4045833
Variance	2.60455377	2.60455377
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	900 Hours	*950 Hours*
Mean	12.40458333	12.4045833
Variance	2.60455377	2.60455377
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

Appendix J continued.

Width Ray - between intervals

t-Test: Paired Two Sample for Means

	950 Hours	*1000 Hours*
Mean	12.40458333	12.3922917
Variance	2.60455377	2.64361265
Observations	8	8
Pearson Correlation	0.999899917	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.342544679	
P(T<=t) one-tail	0.110661461	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.221322923	
t Critical two-tail	2.36462256	

Appendix J continued.

Mass Shark

t-Test: Paired Two Sample for Means

	0 Hours	*50 Hours*
Mean	0.140083333	0.1325
Variance	0.005147498	0.004711877
Observations	24	24
Pearson Correlation	0.99856028	
Hypothesized Mean Difference	0	
df	23	
t Stat	7.613661413	
P(T<=t) one-tail	4.96029E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	9.92057E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*100 Hours*
Mean	0.140083333	0.128479167
Variance	0.005147498	0.004468392
Observations	24	24
Pearson Correlation	0.996940964	
Hypothesized Mean Difference	0	
df	23	
t Stat	7.782934862	
P(T<=t) one-tail	3.42677E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	6.85354E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*150 Hours*
Mean	0.140083333	0.123986111
Variance	0.005147498	0.004137997
Observations	24	24
Pearson Correlation	0.996120811	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.273810035	
P(T<=t) one-tail	1.1981E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.3962E-08	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark

t-Test: Paired Two Sample for Means

	0 Hours	*200 Hours*
Mean	0.140083333	0.121201389
Variance	0.005147498	0.003924128
Observations	24	24
Pearson Correlation	0.995420204	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.305776809	
P(T<=t) one-tail	1.1201E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.2402E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*250 Hours*
Mean	0.140083333	0.118439583
Variance	0.005147498	0.003780796
Observations	24	24
Pearson Correlation	0.995500816	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.807907464	
P(T<=t) one-tail	3.96018E-09	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	7.92037E-09	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*300 Hours*
Mean	0.140083333	0.11754375
Variance	0.005147498	0.003678277
Observations	24	24
Pearson Correlation	0.995795602	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.736683594	
P(T<=t) one-tail	4.58021E-09	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	9.16042E-09	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark

t-Test: Paired Two Sample for Means

	0 Hours	*350 Hours*
Mean	0.140083333	0.114979167
Variance	0.005147498	0.003528677
Observations	24	24
Pearson Correlation	0.994057845	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.63164481	
P(T<=t) one-tail	5.68296E-09	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.13659E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*400 Hours*
Mean	0.140083333	0.112763889
Variance	0.005147498	0.003334162
Observations	24	24
Pearson Correlation	0.992795465	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.368078484	
P(T<=t) one-tail	9.82753E-09	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.96551E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*450 Hours*
Mean	0.140083333	0.111444444
Variance	0.005147498	0.003300533
Observations	24	24
Pearson Correlation	0.99376697	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.773069534	
P(T<=t) one-tail	4.25185E-09	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	8.5037E-09	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark

t-Test: Paired Two Sample for Means

	0 Hours	*500 Hours*
Mean	0.140083333	0.1091875
Variance	0.005147498	0.003114295
Observations	24	24
Pearson Correlation	0.991744155	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.458529148	
P(T<=t) one-tail	8.13509E-09	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.62702E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*550 Hours*
Mean	0.140083333	0.107791667
Variance	0.005147498	0.003014375
Observations	24	24
Pearson Correlation	0.990787997	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.381418781	
P(T<=t) one-tail	9.55672E-09	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.91134E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*600 Hours*
Mean	0.140083333	0.106048611
Variance	0.005147498	0.002887796
Observations	24	24
Pearson Correlation	0.989505879	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.283074863	
P(T<=t) one-tail	1.17494E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.34987E-08	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark

t-Test: Paired Two Sample for Means

	0 Hours	*650 Hours*
Mean	0.140083333	0.105694444
Variance	0.005147498	0.002854352
Observations	24	24
Pearson Correlation	0.989546954	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.262375004	
P(T<=t) one-tail	1.22734E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.45469E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*700 Hours*
Mean	0.140083333	0.103923611
Variance	0.005147498	0.002763671
Observations	24	24
Pearson Correlation	0.987464649	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.23927249	
P(T<=t) one-tail	1.28869E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.57738E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*750 Hours*
Mean	0.140083333	0.103833333
Variance	0.005147498	0.00275943
Observations	24	24
Pearson Correlation	0.987462037	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.246505898	
P(T<=t) one-tail	1.26915E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.5383E-08	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark

t-Test: Paired Two Sample for Means

	0 Hours	*800 Hours*
Mean	0.140083333	0.102041667
Variance	0.005147498	0.002716489
Observations	24	24
Pearson Correlation	0.985496902	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.387942151	
P(T<=t) one-tail	9.4271E-09	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.88542E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*850 Hours*
Mean	0.140083333	0.101479167
Variance	0.005147498	0.002630112
Observations	24	24
Pearson Correlation	0.98483651	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.212893432	
P(T<=t) one-tail	1.36261E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.72522E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*900 Hours*
Mean	0.140083333	0.100083333
Variance	0.005147498	0.002545162
Observations	24	24
Pearson Correlation	0.983037127	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.162587181	
P(T<=t) one-tail	1.51593E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	3.03186E-08	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark

t-Test: Paired Two Sample for Means

	0 Hours	*950 Hours*
Mean	0.140083333	0.099763889
Variance	0.005147498	0.002524227
Observations	24	24
Pearson Correlation	0.982994471	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.166366247	
P(T<=t) one-tail	1.50382E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	3.00764E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	0 Hours	*1000 Hours*
Mean	0.140083333	0.098680556
Variance	0.005147498	0.0024712
Observations	24	24
Pearson Correlation	0.981897243	
Hypothesized Mean Difference	0	
df	23	
t Stat	8.181168557	
P(T<=t) one-tail	1.45733E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.91466E-08	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark - between intervals

t-Test: Paired Two Sample for Means

	50 Hours	*100 Hours*
Mean	0.1325	0.128479167
Variance	0.004711877	0.004468392
Observations	24	24
Pearson Correlation	0.999596688	
Hypothesized Mean Difference	0	
df	23	
t Stat	7.482262456	
P(T<=t) one-tail	6.62723E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.32545E-07	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	100 Hours	*150 Hours*
Mean	0.128479167	0.123986111
Variance	0.004468392	0.004137997
Observations	24	24
Pearson Correlation	0.999765199	
Hypothesized Mean Difference	0	
df	23	
t Stat	7.611215097	
P(T<=t) one-tail	4.98701E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	9.97402E-08	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	150 Hours	*200 Hours*
Mean	0.123986111	0.121201389
Variance	0.004137997	0.003924128
Observations	24	24
Pearson Correlation	0.999788744	
Hypothesized Mean Difference	0	
df	23	
t Stat	6.402784927	
P(T<=t) one-tail	7.79621E-07	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.55924E-06	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark - between intervals

t-Test: Paired Two Sample for Means

	200 Hours	*250 Hours*
Mean	0.121201389	0.118439583
Variance	0.003924128	0.003780796
Observations	24	24
Pearson Correlation	0.999737699	
Hypothesized Mean Difference	0	
df	23	
t Stat	7.387891476	
P(T<=t) one-tail	8.17173E-08	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.63435E-07	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	250 Hours	*300 Hours*
Mean	0.118439583	0.11754375
Variance	0.003780796	0.003678277
Observations	24	24
Pearson Correlation	0.999712049	
Hypothesized Mean Difference	0	
df	23	
t Stat	2.598618576	
P(T<=t) one-tail	0.008029734	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.016059467	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	300 Hours	*350 Hours*
Mean	0.11754375	0.114979167
Variance	0.003678277	0.003528677
Observations	24	24
Pearson Correlation	0.999647518	
Hypothesized Mean Difference	0	
df	23	
t Stat	6.210433625	
P(T<=t) one-tail	1.22803E-06	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	2.45606E-06	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark - between intervals

t-Test: Paired Two Sample for Means

	350 Hours	*400 Hours*
Mean	0.114979167	0.112763889
Variance	0.003528677	0.003334162
Observations	24	24
Pearson Correlation	0.9996243	
Hypothesized Mean Difference	0	
df	23	
t Stat	4.698803991	
P(T<=t) one-tail	4.93055E-05	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	9.8611E-05	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	400 Hours	*450 Hours*
Mean	0.112763889	0.111444444
Variance	0.003334162	0.003300533
Observations	24	24
Pearson Correlation	0.999601841	
Hypothesized Mean Difference	0	
df	23	
t Stat	3.914406806	
P(T<=t) one-tail	0.00034781	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.000695621	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	450 Hours	*500 Hours*
Mean	0.111444444	0.1091875
Variance	0.003300533	0.003114295
Observations	24	24
Pearson Correlation	0.999790361	
Hypothesized Mean Difference	0	
df	23	
t Stat	5.495311969	
P(T<=t) one-tail	6.88498E-06	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.377E-05	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark - between intervals

t-Test: Paired Two Sample for Means

	500 Hours	*550 Hours*
Mean	0.1091875	0.107791667
Variance	0.003114295	0.003014375
Observations	24	24
Pearson Correlation	0.999898472	
Hypothesized Mean Difference	0	
df	23	
t Stat	5.704916778	
P(T<=t) one-tail	4.13232E-06	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	8.26464E-06	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	550 Hours	*600 Hours*
Mean	0.107791667	0.106048611
Variance	0.003014375	0.002887796
Observations	24	24
Pearson Correlation	0.999716741	
Hypothesized Mean Difference	0	
df	23	
t Stat	4.906500644	
P(T<=t) one-tail	2.94114E-05	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	5.88228E-05	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	600 Hours	*650 Hours*
Mean	0.106048611	0.105694444
Variance	0.002887796	0.002854352
Observations	24	24
Pearson Correlation	0.999916713	
Hypothesized Mean Difference	0	
df	23	
t Stat	2.286862559	
P(T<=t) one-tail	0.01586779	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.03173558	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark - between intervals

t-Test: Paired Two Sample for Means

	650 Hours	*700 Hours*
Mean	0.105694444	0.103923611
Variance	0.002854352	0.002763671
Observations	24	24
Pearson Correlation	0.999507296	
Hypothesized Mean Difference	0	
df	23	
t Stat	4.637430218	
P(T<=t) one-tail	5.74527E-05	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.000114905	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	700 Hours	*750 Hours*
Mean	0.103923611	0.103833333
Variance	0.002763671	0.00275943
Observations	24	24
Pearson Correlation	0.999982373	
Hypothesized Mean Difference	0	
df	23	
t Stat	1.405740284	
P(T<=t) one-tail	0.086583462	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.173166925	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	750 Hours	*800 Hours*
Mean	0.103833333	0.102041667
Variance	0.00275943	0.002716489
Observations	24	24
Pearson Correlation	0.999698476	
Hypothesized Mean Difference	0	
df	23	
t Stat	6.507189213	
P(T<=t) one-tail	6.10337E-07	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	1.22067E-06	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark - between intervals

t-Test: Paired Two Sample for Means

	800 Hours	*850 Hours*
Mean	0.102041667	0.101479167
Variance	0.002716489	0.002630112
Observations	24	24
Pearson Correlation	0.999869449	
Hypothesized Mean Difference	0	
df	23	
t Stat	2.332570892	
P(T<=t) one-tail	0.014391388	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.028782775	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	850 Hours	*900 Hours*
Mean	0.101479167	0.100083333
Variance	0.002630112	0.002545162
Observations	24	24
Pearson Correlation	0.99961576	
Hypothesized Mean Difference	0	
df	23	
t Stat	4.172761671	
P(T<=t) one-tail	0.000183024	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.000366047	
t Critical two-tail	2.068654794	

t-Test: Paired Two Sample for Means

	900 Hours	*950 Hours*
Mean	0.100083333	0.099763889
Variance	0.002545162	0.002524227
Observations	24	24
Pearson Correlation	0.999841321	
Hypothesized Mean Difference	0	
df	23	
t Stat	1.699805121	
P(T<=t) one-tail	0.051326912	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.102653824	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Shark - between intervals

t-Test: Paired Two Sample for Means

	950 Hours	*1000 Hours*
Mean	0.099763889	0.098680556
Variance	0.002524227	0.0024712
Observations	24	24
Pearson Correlation	0.999781681	
Hypothesized Mean Difference	0	
df	23	
t Stat	4.530996532	
P(T<=t) one-tail	7.49137E-05	
t Critical one-tail	1.713870006	
P(T<=t) two-tail	0.000149827	
t Critical two-tail	2.068654794	

Appendix J continued.

Mass Ray

t-Test: Paired Two Sample for Means

	0 Hours	*50 Hours*
Mean	0.116708333	0.116583333
Variance	0.001802808	0.001814476
Observations	8	8
Pearson Correlation	0.999994781	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.820930936	
P(T<=t) one-tail	0.055708234	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.111416467	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*100 Hours*
Mean	0.116708333	0.116541667
Variance	0.001802808	0.001816498
Observations	8	8
Pearson Correlation	0.999983033	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.59544807	
P(T<=t) one-tail	0.077321132	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.154642264	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*150 Hours*
Mean	0.116708333	0.115770833
Variance	0.001802808	0.001839682
Observations	8	8
Pearson Correlation	0.999619944	
Hypothesized Mean Difference	0	
df	7	
t Stat	2.115619211	
P(T<=t) one-tail	0.03609348	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.072186961	
t Critical two-tail	2.36462256	

Appendix J continued.

Mass Ray

t-Test: Paired Two Sample for Means

	0 Hours	*200 Hours*
Mean	0.116708333	0.1151875
Variance	0.001802808	0.001856575
Observations	8	8
Pearson Correlation	0.99958644	
Hypothesized Mean Difference	0	
df	7	
t Stat	3.11394392	
P(T<=t) one-tail	0.008493559	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.016987117	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*250 Hours*
Mean	0.116708333	0.113791667
Variance	0.001802808	0.001814387
Observations	8	8
Pearson Correlation	0.998346371	
Hypothesized Mean Difference	0	
df	7	
t Stat	3.36787657	
P(T<=t) one-tail	0.00597747	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.011954939	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*300 Hours*
Mean	0.116708333	0.113791667
Variance	0.001802808	0.001814387
Observations	8	8
Pearson Correlation	0.998346371	
Hypothesized Mean Difference	0	
df	7	
t Stat	3.36787657	
P(T<=t) one-tail	0.00597747	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.011954939	
t Critical two-tail	2.36462256	

Appendix J continued.

Mass Ray

t-Test: Paired Two Sample for Means

	0 Hours	*350 Hours*
Mean	0.116708333	0.113791667
Variance	0.001802808	0.001814387
Observations	8	8
Pearson Correlation	0.998346371	
Hypothesized Mean Difference	0	
df	7	
t Stat	3.36787657	
P(T<=t) one-tail	0.00597747	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.011954939	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*400 Hours*
Mean	0.116708333	0.113125
Variance	0.001802808	0.001823062
Observations	8	8
Pearson Correlation	0.998452734	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.257634435	
P(T<=t) one-tail	0.001878772	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.003757543	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*450 Hours*
Mean	0.116708333	0.113125
Variance	0.001802808	0.001823062
Observations	8	8
Pearson Correlation	0.998452734	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.257634435	
P(T<=t) one-tail	0.001878772	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.003757543	
t Critical two-tail	2.36462256	

Appendix J continued.

Mass Ray

t-Test: Paired Two Sample for Means

	0 Hours	*500 Hours*
Mean	0.116708333	0.113125
Variance	0.001802808	0.001823062
Observations	8	8
Pearson Correlation	0.998452734	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.257634435	
P(T<=t) one-tail	0.001878772	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.003757543	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*550 Hours*
Mean	0.116708333	0.1129375
Variance	0.001802808	0.001812468
Observations	8	8
Pearson Correlation	0.998229922	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.211906488	
P(T<=t) one-tail	0.001988163	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.003976325	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*600 Hours*
Mean	0.116708333	0.1125625
Variance	0.001802808	0.001762111
Observations	8	8
Pearson Correlation	0.998817396	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.560047624	
P(T<=t) one-tail	0.000425436	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.000850872	
t Critical two-tail	2.36462256	

Appendix J continued.

Mass Ray

t-Test: Paired Two Sample for Means

	0 Hours	*650 Hours*
Mean	0.116708333	0.112270833
Variance	0.001802808	0.001777388
Observations	8	8
Pearson Correlation	0.998371584	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.158428459	
P(T<=t) one-tail	0.000655866	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001311733	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*700 Hours*
Mean	0.116708333	0.111875
Variance	0.001802808	0.001763331
Observations	8	8
Pearson Correlation	0.998131632	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.211556673	
P(T<=t) one-tail	0.000618604	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001237209	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*750 Hours*
Mean	0.116708333	0.111875
Variance	0.001802808	0.001763331
Observations	8	8
Pearson Correlation	0.998131632	
Hypothesized Mean Difference	0	
df	7	
t Stat	5.211556673	
P(T<=t) one-tail	0.000618604	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001237209	
t Critical two-tail	2.36462256	

Appendix J continued.

Mass Ray

t-Test: Paired Two Sample for Means

	0 Hours	*800 Hours*
Mean	0.116708333	0.1115625
Variance	0.001802808	0.001764261
Observations	8	8
Pearson Correlation	0.997607618	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.922730411	
P(T<=t) one-tail	0.000854164	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001708328	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*850 Hours*
Mean	0.116708333	0.1115625
Variance	0.001802808	0.001764261
Observations	8	8
Pearson Correlation	0.997607618	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.922730411	
P(T<=t) one-tail	0.000854164	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001708328	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	O Hours	*900 Hours*
Mean	0.116708333	0.111083333
Variance	0.001802808	0.001764563
Observations	8	8
Pearson Correlation	0.996805255	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.671068558	
P(T<=t) one-tail	0.001142314	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.002284627	
t Critical two-tail	2.36462256	

Appendix J continued.

Mass Ray

t-Test: Paired Two Sample for Means

	0 Hours	*950 Hours*
Mean	0.116708333	0.1109375
Variance	0.001802808	0.001774642
Observations	8	8
Pearson Correlation	0.996945128	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.912640562	
P(T<=t) one-tail	0.000864027	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.001728054	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	0 Hours	*1000 Hours*
Mean	0.116708333	0.109520833
Variance	0.001802808	0.001677003
Observations	8	8
Pearson Correlation	0.997426085	
Hypothesized Mean Difference	0	
df	7	
t Stat	6.067590222	
P(T<=t) one-tail	0.000253525	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.00050705	
t Critical two-tail	2.36462256	

Appendix J continued.

Mass Ray - between intervals

t-Test: Paired Two Sample for Means

	50 hours	*100 Hours*
Mean	0.116583333	0.116541667
Variance	0.001814476	0.001816498
Observations	8	8
Pearson Correlation	0.99999633	
Hypothesized Mean Difference	0	
df	7	
t Stat	1	
P(T<=t) one-tail	0.175308331	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.350616663	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	100 Hours	*150 Hours*
Mean	0.116541667	0.115770833
Variance	0.001816498	0.001839682
Observations	8	8
Pearson Correlation	0.999629505	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.824441371	
P(T<=t) one-tail	0.055422397	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.110844794	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	150 Hours	*200 Hours*
Mean	0.115770833	0.1151875
Variance	0.001839682	0.001856575
Observations	8	8
Pearson Correlation	0.999881612	
Hypothesized Mean Difference	0	
df	7	
t Stat	2.390955179	
P(T<=t) one-tail	0.024050617	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.048101234	
t Critical two-tail	2.36462256	

Appendix J continued.

Mass Ray - between intervals

t-Test: Paired Two Sample for Means

	200 Hours	*250 Hours*
Mean	0.1151875	0.113791667
Variance	0.001856575	0.001814387
Observations	8	8
Pearson Correlation	0.999259711	
Hypothesized Mean Difference	0	
df	7	
t Stat	2.294805086	
P(T<=t) one-tail	0.02770685	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.055413699	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	250 Hours	*300 Hours*
Mean	0.113791667	0.113791667
Variance	0.001814387	0.001814387
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	300 Hours	*350 Hours*
Mean	0.113791667	0.113791667
Variance	0.001814387	0.001814387
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

Appendix J continued.

Mass Ray - between intervals

t-Test: Paired Two Sample for Means

	350 Hours	*400 Hours*
Mean	0.113791667	0.113125
Variance	0.001814387	0.001823062
Observations	8	8
Pearson Correlation	0.999527191	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.433543118	
P(T<=t) one-tail	0.097409641	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.194819283	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	400 Hours	*450 Hours*
Mean	0.113125	0.113125
Variance	0.001823062	0.001823062
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	450 Hours	*500 Hours*
Mean	0.113125	0.113125
Variance	0.001823062	0.001823062
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

Appendix J continued.

Mass Ray - between intervals

t-Test: Paired Two Sample for Means

	500 Hours	*550 Hours*
Mean	0.113125	0.1129375
Variance	0.001823062	0.001812468
Observations	8	8
Pearson Correlation	0.999926884	
Hypothesized Mean Difference	0	
df	7	
t Stat	1	
P(T<=t) one-tail	0.175308331	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.350616663	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	550 Hours	*600 Hours*
Mean	0.1129375	0.1125625
Variance	0.001812468	0.001762111
Observations	8	8
Pearson Correlation	0.999784491	
Hypothesized Mean Difference	0	
df	7	
t Stat	1	
P(T<=t) one-tail	0.175308331	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.350616663	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	600 Hours	*650 Hours*
Mean	0.1125625	0.112270833
Variance	0.001762111	0.001777388
Observations	8	8
Pearson Correlation	0.999817039	
Hypothesized Mean Difference	0	
df	7	
t Stat	1	
P(T<=t) one-tail	0.175308331	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.350616663	
t Critical two-tail	2.36462256	

Appendix J continued.

Mass Ray - between intervals

t-Test: Paired Two Sample for Means

	650 Hours	*700 Hours*
Mean	0.112270833	0.111875
Variance	0.001777388	0.001763331
Observations	8	8
Pearson Correlation	0.999918361	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.988621781	
P(T<=t) one-tail	0.043534006	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.087068011	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	700 Hours	*750 Hours*
Mean	0.111875	0.111875
Variance	0.001763331	0.001763331
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	750 Hours	*800 Hours*
Mean	0.111875	0.1115625
Variance	0.001763331	0.001764261
Observations	8	8
Pearson Correlation	0.999904557	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.523019248	
P(T<=t) one-tail	0.085785843	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.171571685	
t Critical two-tail	2.36462256	

Appendix J continued.

Mass Ray - between intervals

t-Test: Paired Two Sample for Means

	800 Hours	*850 Hours*
Mean	0.1115625	0.1115625
Variance	0.001764261	0.001764261
Observations	8	8
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	7	
t Stat	#DIV/0!	
P(T<=t) one-tail	#DIV/0!	
t Critical one-tail	#DIV/0!	
P(T<=t) two-tail	#DIV/0!	
t Critical two-tail	#DIV/0!	

t-Test: Paired Two Sample for Means

	850 Hours	*900 Hours*
Mean	0.1115625	0.111083333
Variance	0.001764261	0.001764563
Observations	8	8
Pearson Correlation	0.999771866	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.510489102	
P(T<=t) one-tail	0.087333838	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.174667676	
t Critical two-tail	2.36462256	

t-Test: Paired Two Sample for Means

	900 Hours	*950 Hours*
Mean	0.111083333	0.1109375
Variance	0.001764563	0.001774642
Observations	8	8
Pearson Correlation	0.999982892	
Hypothesized Mean Difference	0	
df	7	
t Stat	1.507157317	
P(T<=t) one-tail	0.087749725	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.175499449	
t Critical two-tail	2.36462256	

Appendix J continued.

Mass Ray - between intervals

t-Test: Paired Two Sample for Means

	950 Hours	*1000 Hours*
Mean	0.1109375	0.109520833
Variance	0.001774642	0.001677003
Observations	8	8
Pearson Correlation	0.99991038	
Hypothesized Mean Difference	0	
df	7	
t Stat	3.081826176	
P(T<=t) one-tail	0.008884872	
t Critical one-tail	1.894577508	
P(T<=t) two-tail	0.017769743	
t Critical two-tail	2.36462256	

Appendix J continued.

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